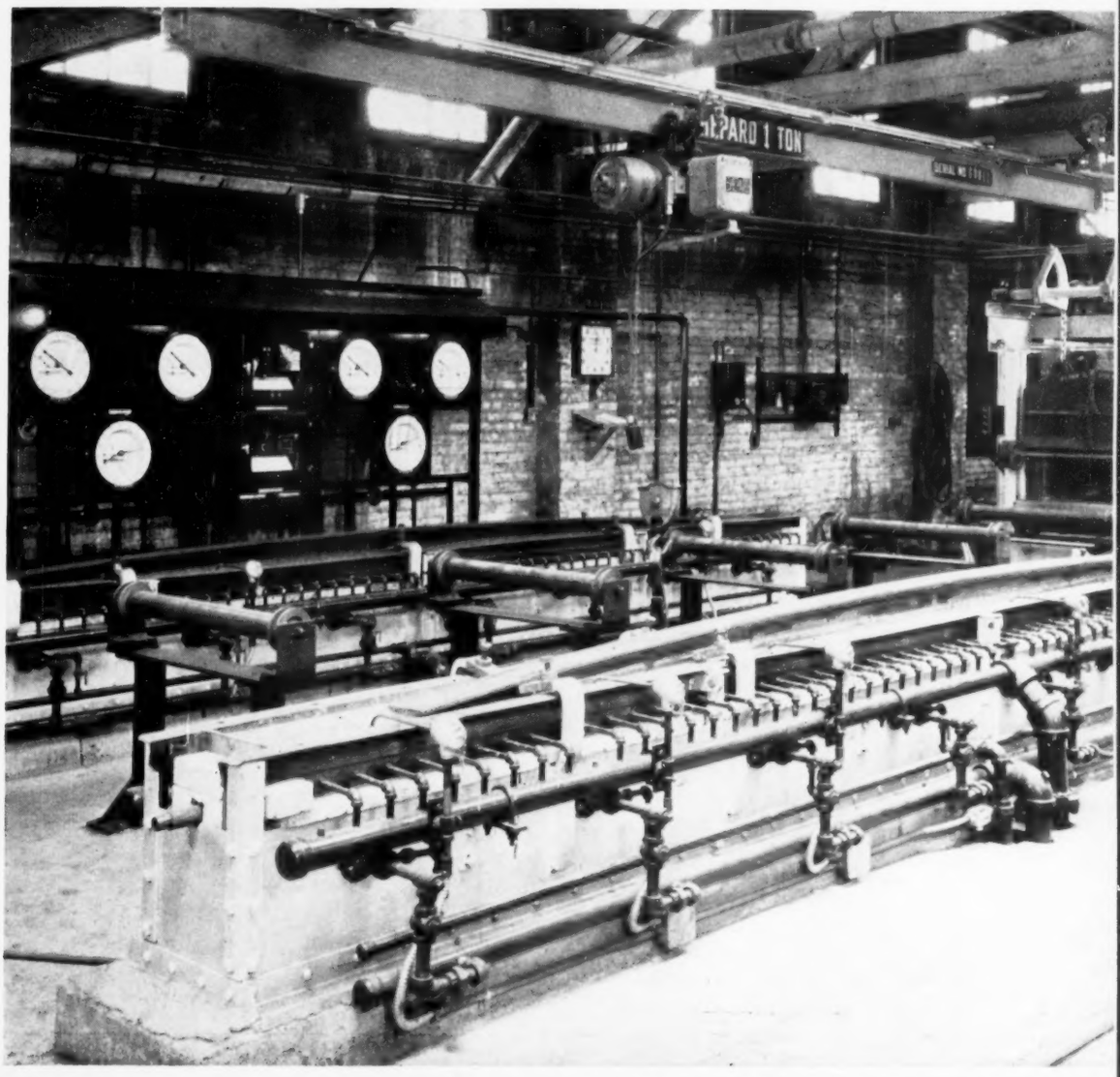
THE MAGAZINE OF

MEASUREMENT and CONTROL

INSTRUMENTS



INSTRUMENTATION OF RAIL HARDENING FURNACE AND LEAD POTS AT CHICAGO PLANT OF RAMAPO AJAX CORPORATION. *Courtesy Leeds & Northrup Co.*

RECORDING NITRIC OXIDE *See Page 161*

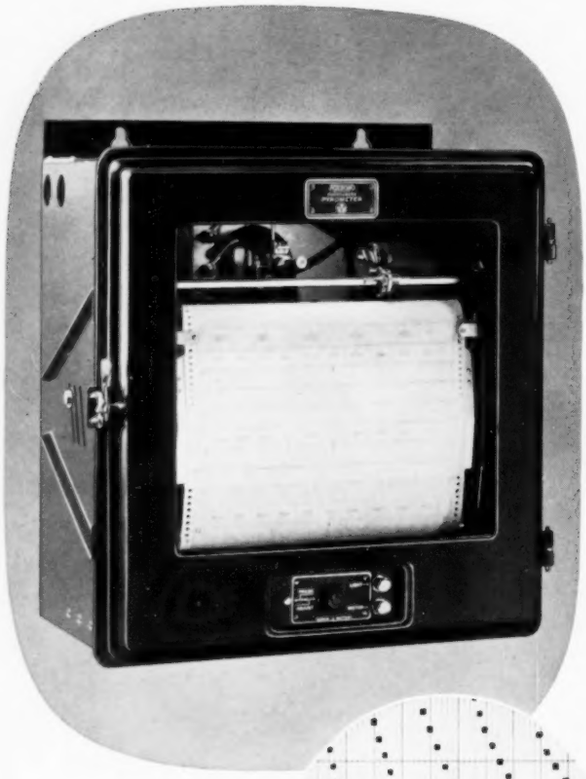
THE NEW INSTRUMENT BATTERIES *See Page 164*

VOLUME 9

JUNE

1936

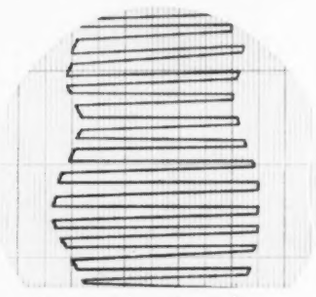
NUMBER 6



5 Different Kinds of Temperature Records

Six records in separate colors.

Six records in colored dots.



Two-record continuous line.

Single-record continuous line.

Eight different temperatures on one chart.

The Improved Foxboro Potentiometer Recorder offers a type of record to fit your individual problem

Do you want to record one temperature; or eight different temperatures on the same chart? The new-series Foxboro Potentiometer Pyrometer offers you a choice of five different styles of record—from the continuous red line of a single-point machine to the six numerals in different colors or the eight numerals in one color.

This wide choice of records is but one of *scores* of improved features you'll find in the improved Foxboro Potentiometer. Others include the exclusive *compensating* slide-wire—integral mounting of slide-wire contact and pen carriage—rugged, yet super-sensitive galvanometer. All are fully explained and illustrated in new Bulletin 190-1. *Send for your copy.*

THE FOXBORO COMPANY
46 Neponset Ave., Foxboro, Mass., U.S.A.

Branch Offices in 20 Principal Cities

POTENTIOMETERS
Indicating
Recording
Controlling

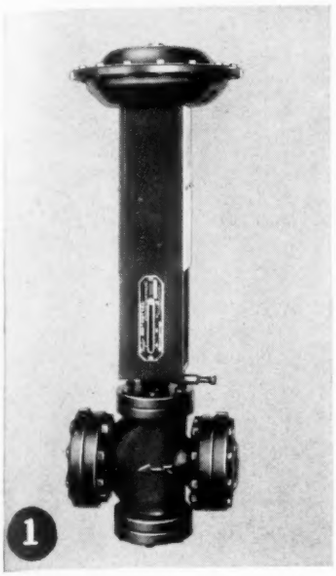
MILLIVOLTMETERS
Indicating
Recording

ELECTRIC RESISTANCE THERMOMETERS
Indicating
Recording
Controlling

FOXBORO
REG. U.S. PAT. OFF.
PYROMETERS

• COMPLETE INDUSTRIAL INSTRUMENTATION •

4 NEW THINGS IN TEMPERATURE CONTROL



1. TAYLOR MOTOSTEEL EVENACTION VALVE. The first valve motor with all-steel welded construction. Lighter in weight than cast iron motors but much stronger—with greater resistance to shocks and strains. Larger diaphragm and longer, heavier spring, totally enclosed. Roller-bearing stem guide. Valve position indicator. All parts specially treated to resist corrosion, and all parts readily accessible.

These and many other features make this new Taylor valve the most efficient and up-to-date of its type.

Taylor presents...

1. New Taylor Motosteel Evenaction Valve

2. New Taylor Indicating Controller

3. New Taylor Valv-Precisor

4. New Taylor Thermospeed Separable Well Tube System

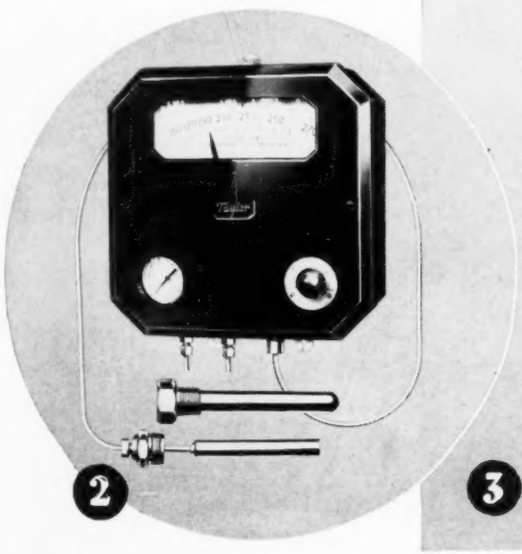
HERE is a record of achievement in the field of instrumentation. Not one or two—but four—developments of major importance to industry. If you are interested in automatic plant control, then you are concerned with automatic control of temperature.

AND...

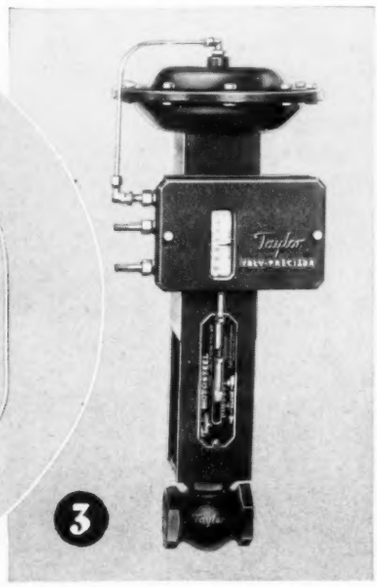
You certainly will be interested in every one of these Taylor Instruments and Systems of Control.

Along with these products—outstanding in accuracy, efficiency, economical operation—you receive the benefit of the widest experience in dealing with problems relating to temperature, pressure, flow and liquid level that is possessed by any one single group.

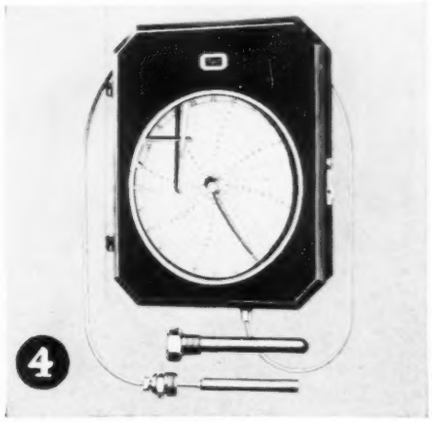
Let Taylor Engineers survey your plant and prescribe for your needs. If you need modernization or extension of present temperature control, let it be Taylor Control. For this service and detailed data *on any Taylor* products, address Taylor Instrument Companies, Rochester, N. Y. Plant also in Toronto, Canada. Manufacturers in Great Britain —Short & Mason, Ltd., London, England.



2. TAYLOR INDICATING CONTROLLER. This 86-R Type "Fulscope" Temperature Controller is for either high range or full range sensitivity applications. Has all "Fulscope" advantages, including "Sensitivity Adjuster," which makes adjustments with the turn of a screwdriver. Direct or reverse action. Mercury-, vapor-, or gas-actuated types. Adjustable to practically any operating condition.



3. TAYLOR VALV-PRECISOR. Every diaphragm valve has a certain degree of hysteresis, due largely to the friction of the valve stem in the valve stuffing box. Taylor developed this Valv-Precisor to eliminate practically all hysteresis and assure precision valve action for any air-operated controller. Under many operating conditions it will make your present valves perform more efficiently.



4. TAYLOR THERMOSPEED. A new construction for separable well tube systems that responds to temperature changes at the bulb six times faster than the average now in use. Makes Taylor Instruments even more accurate and efficient. Eliminates bulb conduction error. See above a Taylor Recorder with new Thermospeed construction.

Taylor

Indicating | Recording • Controlling

TEMPERATURE, PRESSURE *and* **FLOW INSTRUMENTS**

INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

IN THIS ISSUE

When, in the manufacture of any product, it is discovered that as small a concentration of an impurity as one part in 35 million will cause trouble, the chemists are faced with the problem of devising a method whereby the objectionable constituent will be not only detected but accurately measured. W. E. Stackhouse reports the new method whereby such low concentrations of nitric oxide in manufactured gas can be not only measured but continuously recorded. That his apparatus is made up almost entirely of standardized instrumentation devices makes his solution all the more beautiful.

Subscribers' inquiries pertaining to special dry batteries for use in connection with instruments had always perplexed *Instruments'* staff, because so little had been made known by manufacturers or experienced users. We sought an authoritative article. H. E. Lawson contributes an article which is not only authoritative but up-to-the-minute.

Ralph Batcher concludes his treatment of CRO "pick-ups" and begins a discussion of photographic auxiliaries.

This month's chapter of the electrical measurements series deals with the important subject of adjustments which users may make in the field. It was read, in the last few days, by several eminent authorities in the Bureau of Standards and other institutions and companies. They found little to add to Perry Borden's mature advice.

In the July Issue there will be a noteworthy pictorial article on inspection and testing methods at the Ford Motor Co.

THE SMALL PLANT

IN all the years that *Instruments'* staff has been replying to subscribers' inquiries pertaining to the instrumentation of industrial plants, the application of simple statistical methods has at times served useful purposes. We have already referred on this page to seasonal trends, to opportunities for individuals, etc. As a rule, before we analyze a batch of inquiries, we have in mind certain definite bases of classification. That is to say, our usual procedure is like analyzing a group of steel specimens for Si, Mn, C, Ni, and other constituents listed in advance. Mere routine, of course, but it helps us to serve you better by developing a clearer composite-picture of "you."

Until recently, we had never thought of classifying inquiries on the basis of the size of the company by which the inquirer is employed, and correlating this bigness or smallness with other indices. If the idea had come up, it would have been dismissed on the ground that the quantitative results of such a correlation could not possibly be of wide usefulness.

Perhaps this objection still holds true. Perhaps the publication of our findings would only meet with a bored "So what?"

Nevertheless, in these dark times of politico-economic dog fights (where Industry gets bitten with equal ferocity by mangy mongrels, by police pooches and by parlor pets) every little two-penny candle of factual light may serve to dispel some of th'encircling gloom, and we humbly venture to report that—

(1) The proportion of "where-to-buy" inquiries from small plants has risen to about twice the ratio of small to large plants represented by our circulation break-down.

(2) It isn't that large plants have decreased their rate of installing new measurement-and-control devices, but that small plants appear to be modernizing about twice as fast as are large plants—at least, with regard to process control, automatized inspection and other up-to-date applications of instruments.

(3) This shift seems sudden on a ten-year chart where 1936 is compared with the preceding average, but it came gradually, beginning early in 1935; and seems to be approaching a point of inflection.

"So what?" Ours to present, not to interpret. But some other observers are predicting that America is about to witness the rapid growth of new industries now in their infancy . . .

INSTRUMENTS' READERS AT WORK

No. 9 MAURICE L. CARR
Director

No. 10 LAWRENCE K. JONES
Engineer, Special Test Section

Pittsburgh Testing Laboratory, Pittsburgh, Pa.

By M. F. BEHAR

IF we were to print a complete list of the instruments in PTL's five-story headquarters (leaving out its twelve branch laboratories) there would be no space left on this page for biographies and snap-shots of *Instruments'* readers in PTL.

Besides, although a mere list usually tells a vivid story, it would not do it in this case, because many unique items require explanatory notes. Take for instance the item—

Heat & sound transmission and air-infiltration test equipment.

The least we could add in the way of notes would be—

—as big as a bungalow and containing numerous detectors all connected to measuring instruments set up on the outside.

In fact, a ten-page article could be written about this one item and the research projects it has made possible!

Or, if we were to print a series of interviews with all our readers in PTL, with snap-shots of each at his work but no instrument lists, it would take several pages. Director Carr, for example, cannot be adequately introduced to his fellow-subscribers in one brief paragraph: we spent several weeks, back in 1922, writing a little book on the technique of testing fire-resistant office safes, which book was based on Carr's pioneering achievements at Underwriters' Laboratories between 1907 and 1920 . . . and Carr has blazed new trails in other fields of testing, each deserving a book. Suffice it to say, for the benefit of our younger subscribers, that Carr began as a meter tester for the Peoria Gas & Electric Co. *before* entering the University of Illinois where he took two degrees. This was 33 years ago . . . when there was born the very man on whom Carr now relies for supervising certain important tests. Despite his youth, Jones has a seven-year record of instrumentation work. Despite his M.E. degree (Carnegie Tech) his work at PTL is mostly electrical and electronic. He is an avid student, devouring every issue of *Instruments* and attending night courses at Tech. He was married three days before we interviewed him, and when we did so it was not at Niagara Falls but at the very spot where this snapshot was taken! Such self-sacrifice indicates an almost passionate love for instruments (small i), not necessarily for *Instruments*. We deliberately lay stress on this distinction. We resolutely turn down our circulation department's bright ideas about married subscribers finding *Instruments* more fascinating than . . .

PARTIAL LIST OF PTL's INSTRUMENTS

GENERAL

Barometers, hygrometers, psychrometers; thermometers, kata-thermometers, pyrometers; pressure & vacuum gages, 6000 lbs./in.^{2} dead weight tester; pitot tubes; anemometers; fluid meters; watthour meters, electrical instruments and standards; micrometers, dial indicators, planimeters, microscopes, extensometers.

CEMENT & CONCRETE LABORATORY

ASTM equipments; Deval abrasion apparatus; core drills; brick rattlers; Talbot-Jones concrete block rattler; permeability apparatus; briquette testing machines; foundry sand testers; 30,000-lb. compression testing machine; assortment of standard weights, measures and sieves.

METALS LABORATORY

4 universal testing machines (< 600,000 lbs.); Izod impact tester; torsion testing machine; Moore fatigue apparatus; dilatometers; Rockwell, Brinell and Scleroscope hardness testers; Amsler calibrating box; high-temperature tensile strength equipment.

METALLOGRAPHIC LABORATORY

Complete Zeiss equipment, polishing equipments, specimen mounting press, etc.

HIGH-TEMPERATURE LABORATORY

6 furnaces; complete pyrometric & physical measuring equipments.

DIELECTRIC TESTING LABORATORY

60,000-volt equipment & accessories.

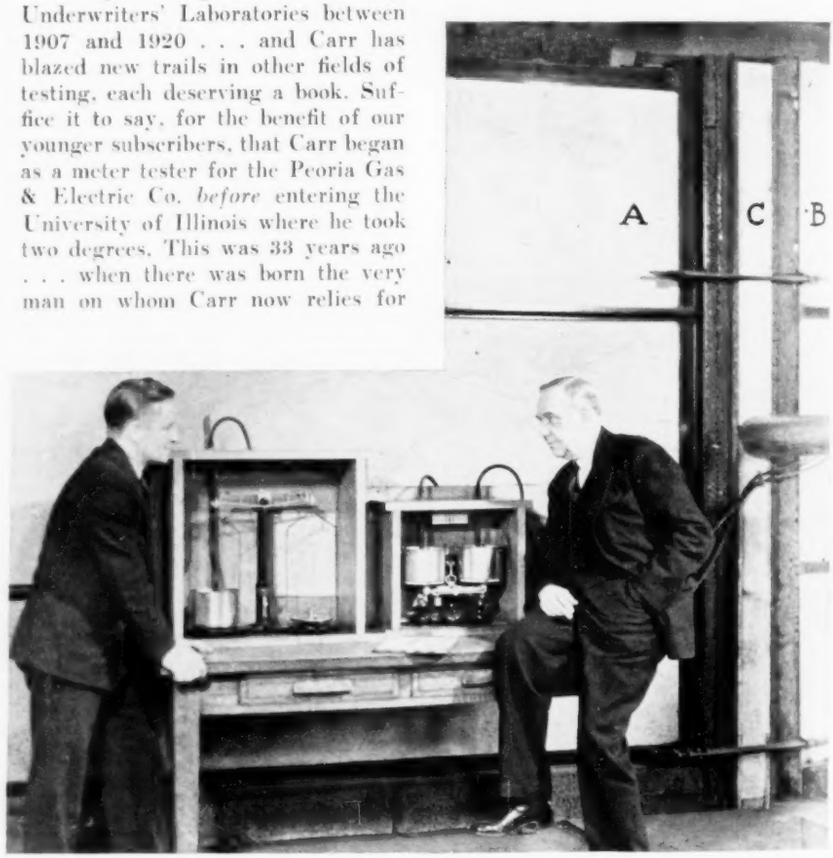
CHEMICAL LABORATORIES

(1) OIL & GAS: Saybolt viscosimeter, Pensky-Marten and TAG flash testers, Emley plasticimeter, asphalt ductility apparatus, ASTM distillation apparatus, Edwards gas balance, standard gas analysis apparatus, gas detectors, Junkers & Parr calorimeters, Haldane apparatus, SO_2 apparatus, Selby apparatus.

(2) MISCELLANEOUS: pH potentiometer, electrometric & other titration equipment, turbidimeters, Weatherometer, salt spray cabinets, glossometers, Owens dust counter, Greenburg-Smith impinger apparatus, bacteriological equipments, etc.

SPECIAL EQUIPMENTS

12" hot-plate with 0°F. cold-plate thermal conductivity apparatus
8" thermal conductivity apparatus
Heat & sound transmission and air-infiltration test equipment
Sound generating, measuring and analyzing equipments
Light sources and illuminometers
Testers for fabrics, carpets and other textile products
Fan efficiency tester (pendulum type)
ASTM-CFR octane rating engine
Vibration-insulation tester
Timken lubricant-testing machine
Cadmann bearing-metal-testing machine
Full-size building-wall insulation volume-reduction apparatus
Various types of exposure racks on roof
Photographic equipments



PTL Cameraman Jamison caught Jones (left) telling Director Carr about infiltration characteristics of a full-size window built into wall section C between sealed rooms A and B, pressures and differentials being ingeniously "weighed" in oil-sealed bells on scale pans. Apparatus serves also for wall-section insulation-value tests by maintaining room A at —40°F. and room B at 80°F. and measuring heat flow; or by generating standard sounds within A and setting up electric ears in B.

THE MONTH'S NEW INSTRUMENTS

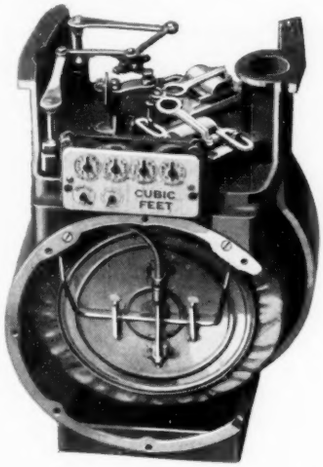
In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

Or write to Information Section, Instruments Publishing Company.

Oxygen Meter

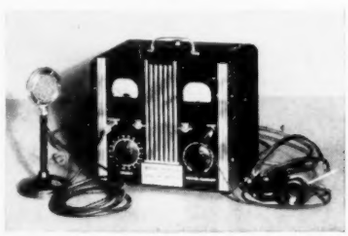
Said to represent two years of research with coöperation of laboratories of largest oxygen producers, this diaphragm-type meter especially adapted to the



measurement of oxygen is of maker's standardized "Ironcase" design, but the materials used in its construction are selected especially for this service. Available for low-pressure service as well as high pressures. Where used for measuring high-pressure oxygen, meter should be equipped with a Volume & Pressure Gage, a Base Pressure Index or a Base Volume Index.—*American Meter Co., 60 E. 42nd St., New York City.*

Sound Level Indicator

"Model 300" Sound Level Indicator, designed for measuring the intensity and character of sounds as they are actually heard by the human ear, consists of: (1) a calibrated crystal type microphone; (2) a high-gain audio-frequency



amplifier; (3) a calibrated attenuator for increasing db range; (4) an ear weighing filter, which may be cut out so that the decibel meter will respond to all sounds of equal intensity with equal deflection, to permit use of frequency analyzer unit or oscillograph; (5) a calibrated output or decibel meter of rectifier-milliammeter type; (6) a crystal type head set. "Model 300" has a reference level of 10^{-16} watts. Frequency used as a basis of calibration is 1000 cycles. This practice conforms to the proposed standards of the A.S.A.—*Industrial Apparatus Co., 720 N. Wabash Ave., Chicago, Ill.*

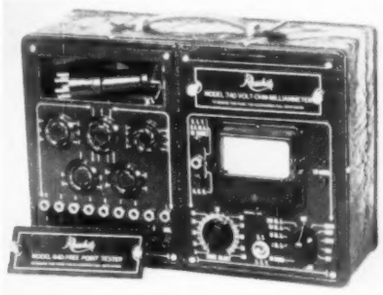
High-speed Motion-picture Equipment

Sharp motion pictures of mechanisms, etc., at speeds <2000 exposures per sec., are obtained by means of a new equipment comprising: (1) An improved stroboscopic control unit of the Edgerton

type. This unit is the cabinet seen in foreground of illustration; its principle was described in detail in *Instruments*, Jan. 1933, page 23. (2) Type 651-A Camera as described in *Instruments*, Feb. 1935, page 54. (3) A high-voltage motor-generator set of capacity depending on maximum speed and illumination —a 10-kw. set usually being most suitable. (4) Two high-intensity reflecting lamp units which, in conjunction with Edgerton circuit, give out flashes of 0.000005-sec. to 0.00001-sec. duration. Regularity of flashing, at any desired frequency, is attained by use of Thyratron and contactor, latter driven on constant-speed shaft of camera. Illustration shows set-up for photographing a leather-stitching machine.—*General Radio Co., 30 State St., Cambridge, Mass.*

Ranger-Examiner Combination

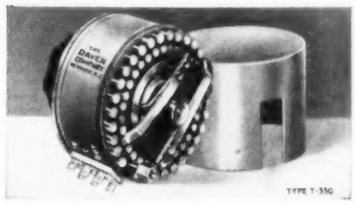
New "Model 640-740" combination free point tester and volt-ohm-milliammeter is said to be adaptable for any purpose in radio voltage, current or resistance



testing, either by direct contact with sockets or by the free point method. It has a Triplett indicating instrument with scale readings: A-c. and d-c. volts, 10-50-250-500-1000 at 1000 ohms per volt; D-c. accuracy 2%; A. C. volts, rectifier type, accuracy 5%. 1-10-50-250 Ma. Low ohms scale 0-300; high ohms to 100,000 with provision to increase scale in 100,000 ohms steps by adding external batteries. Measures low ohms by the backup method without appreciable contact or other errors. Free point tester has five sockets for handling any type tubes. Panel also includes eight automatic switch-type and ten single-action jacks. Handled metal case with black electro-enamel finish, silver and black panels, size $11\frac{5}{16}$" × $7\frac{7}{8}$" × $4\frac{1}{8}$".—*Readrite Meter Works, 326 Harmon Drive, Bluffton, Ohio.*

"T" Attenuator

New "Type T-330" 30-step "T" network is said to be especially applicable to low-level mixing by reason of its zero insertion loss, constant input and output impedance at all settings of the dial,



wide attenuation range, and low switch noise level. Its new wiping type, balanced, smooth-operating, multi-leaf switch is said to have constant torque at all settings. A new type of switch stop removes strain from switch blades. Attenuator is offered in impedances from 30 to 600 ohms with attenuation of 1.5 db per step. Loss per step is increased on the last few contacts. Unequal input and output impedances designed for minimum loss may be obtained upon request. Unit is interchangeable electrically and mechanically with ladder type attenuators. Size: $2\frac{11}{16}$" diam., $2\frac{1}{16}$" back-of-panel space. Net wt. 12 oz.—*The Daven Co., 158 Summit St., Newark, N. J.*

BAILEY METER
CONTROL SYSTEM

The Mark of

Effective Control

Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.

Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

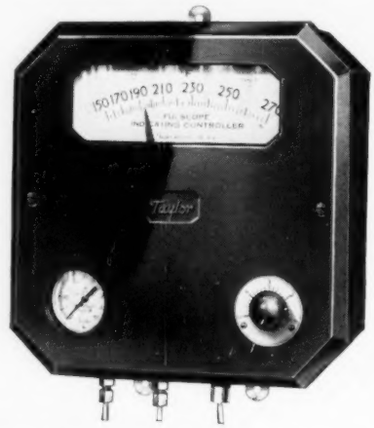
G-3

BAILEY METER COMPANY

1041 Ivanhoe Rd., Cleveland, Ohio

Non-recording, Air-operated Automatic Controllers

For processes not requiring chart records and yet characterized by lags which necessitate in the control instrument a sliding adjustment providing a full scope of sensitivities, a new line of temperature



and pressure controllers has been developed which retains all the performance characteristics of maker's "Fulscope" recorder-controllers (see *Instruments*, April 1931, page 81). With omission of recording mechanism, new instruments are housed in a smaller black-finished cast-aluminum case, designed for this purpose: sensitivity adjustment to accommodate process lag is made by turning a graduated dial. Control point may be adjusted to any value within control range. Direct-set feature is optional. Controller action may be quickly reversed in the field by altering the position of a link. Standard control ranges are available within the limits of —100°F. and 1200°F., or full vacuum and 3000 lbs. pressure. Control ranges are interchangeable. Temperature controllers may be equipped with mercury-, vapor-, or gas-actuated tube systems.—*Taylor Instrument Companies, 95 Ames St., Rochester, N. Y.*

Light Wave Equipment and Improved Monochromatic Light

New light wave equipment including more accurate and better-wearing optical flats is suitable for testing flatness of commercial flat lapped surfaces or for making length or diameter measurements of precision gage blocks, plug gages or steel balls. Optical flat set (see Fig. 1) consists of two 2″ diam. by $\frac{5}{8}$″ thick single-surface, semi-quartz working flats of 0.000002″ accuracy; one 2″ diam. by $\frac{1}{2}$″ thick double-surface steel working flat of similar accuracy; and one 3″ diam. by $\frac{1}{2}$″ thick single-surface master flat of 0.000001″ accuracy. These flats are twice the accuracy previously guaranteed and the semi-quartz material shows wearing qualities from 3 to 4 times greater than the optical glass of former equipments. Their thickness insures freedom from distortion in use. New monochromatic light source (seen in part in Fig. 1) is an oak cabinet 12″ wide by 11″ high by 11″ deep, with space inside to house a gas-filled tube, with necessary transformer, switch and diffusing glass. Light tube, 10½″ overall with chemically treated electrodes, is filled

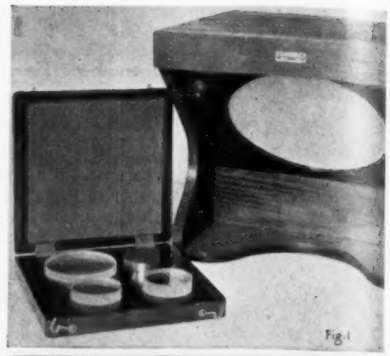


Fig. 1

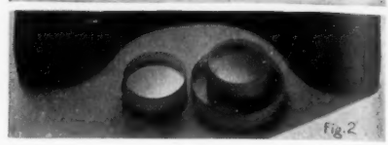


Fig. 2

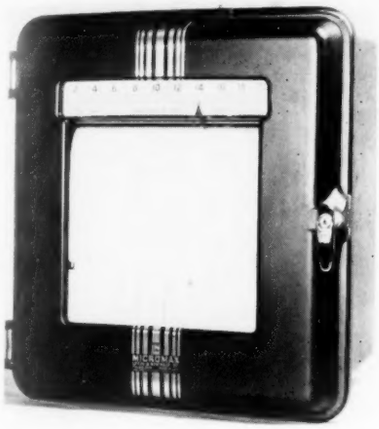
with a special gas that emits a strongly monochromatic light of 11.6 millionths of an inch per dark interference band. Its life is estimated to be from 1000 to 2000 hours continuous use. Performance of new light is shown in Fig. 2 (unretouched photo) which shows interference bands visible in checking the 4 optical flats of the equipment against each other. Light emitted is so strongly monochromatic that bands are clearly visible when separation of surfaces is as much as 0.0005″ (ten times that of former equipments). Thus optical flat need not touch surface being tested. No sliding motion is necessary to exclude air film. Formerly "undesirable" air film now protects optical flat from actual contact and resulting wear. Bands are said to be visible on comparatively dull surfaces such as are common on lapped soft steel or on burnished bronze or brass.—*Van Keuren Co., 12 Copeland St., Watertown, Mass.*

Colorimetric Stand and "Daylight" Illuminator

This new device is used to support and illuminate instruments for determining the A.S.T.M. color of petroleum products: either the TAG-Robinson Colorimeter (as shown in illustration) or the TAG-Saybolt Chromometer. Light source is standard "TAG-Macbeth Daylight Lamp" and diffusion screen (between lamp and instrument) is a flashed opal glass. Both lamp and screen meet latest A.S.T.M. specifications for this equipment. A large oil company suggested this arrangement, finding that more effective illumination is obtained when light from the "daylight" lamp, instead of being reflected, passes directly up through the tubes of the Chromometer or Colorimeter. Illuminator of new stand is so designed that all light is excluded except that coming from the lamp. Color instrument is clamped to removable base which in turn is bolted to adjustable height platform.—*C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.*

Potentiometric or Bridge Recorders and Controllers

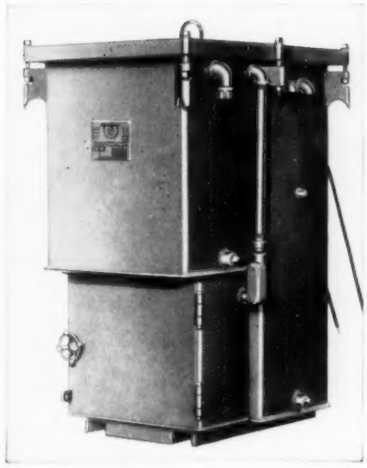
Signalizing 25th year since maker brought out self-balancing recording potentiometers and bridges, "Silver-Anniversary Micromax" line includes indicat-



ing recorders and indicating-recording controllers for temperature, CO_2, smoke density, chemical strength, pH, frequency, remote load, SO_2, liquid level, speed, fluid flow, etc., housed in new case, embodying new interior construction features and employing improved assemblies of the "Micromax" self-balancing mechanism (see *Instruments*, Sept. 1931, page 505; March 1933, page 63). Chief outwardly-visible innovation is convenient presentation of measurements: bold scale and pointer show value of measured condition at the moment, and 10" of strip-chart shows it for the past several hours. On controllers, a second pointer shows control setting. Multi-point records may be in blue or in multi-color. Control and signal contacts operate undisturbed by air currents when door is opened, even when chart is changed or pen refilled. Pen holds 7-week ink supply. Double frame makes all parts of mechanism accessible and enables user to replace chart without effect on other parts of recorder. In the new standard "Micromax" assemblies contacts are heavier and certain other component parts are new.—*Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.*

Feeder-voltage Booster

To improve voltage conditions on circuits where the close regulation provided by station-type regulators is not necessary and where voltage control of any kind has hitherto been considered too expensive, new "Type BR" booster regulator provides a boost of 5% or 10% in one or two steps, as desired, during the heavy-load periods of the outdoor type, it is particularly applicable to rural lines or distribution circuits where the load changes once or twice daily from very light to practically full load. As the supply voltage decreases to, say, 94% of normal, device goes to the boost position and remains there until the supply voltage rises again to, say, 96% of normal. Standard "Type BR" booster is single-phase. Long feeders with induction regulators at the substation may be tapped off at various points. The substation regulator is adjusted to maintain normal voltage at a center of distribution chosen



to take care of the most important load. Low voltage at locations beyond this point can be improved by the new booster. For 3-phase, 3-wire circuits, two units may be connected in open delta. For 3-phase, 4-wire circuits, three units may be connected in star. If desired, two or more banks of boosters may be used in series on the same circuit at different locations along the line. In special cases a booster may be connected for bucking instead of boosting.—*Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

Special-purpose Oscillographs

To meet demand from certain territories, and for special applications, two new types of oscillograph instruments have been added, both identical with the standard RCA Oscillograph (see *Instruments*, May 1935, page 135) except that one operates on the 25-cycle a.c. in use in some areas, and the other has a special sweep oscillator which extends from 4 cycles to 18,000 cycles.—*RCA Parts Div., RCA Mfg. Co., Camden, N. J.*

Photoelectric Relays

A line of d-c. photoelectric relays for operation on 115 and 230 volts now supplements maker's a-c. line. As in latter, the new units are available with 2" and

3" lens apertures, with rectangular cell apertures and no lenses, and with no apertures—these last for use with separate cell housings. Unit illustrated is "No. 5353-C" with 2" aperture, for use on 115 volts d.c. It is housed in a heavy formed steel cabinet for industrial control and commercial applications. Resistor unit is mounted on side as shown. *G-M Laboratories, Inc., 1731 Belmont Ave., Chicago, Ill.*

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Recorder-controllers

A new series of air-operated controllers known as "Ampliset Free-Vane Controllers" are now available for automatically controlling temperature, time-temperature, flow, liquid level, pressure,

time-pressure, and humidity. The "Ampliset" principle has also been combined with the "Metameter" system of telemetering (see *Instruments*, Feb. 1934, page 36; Jan. 1935, page 23) for the remote control of steam pressure and gas pressure. The new controllers operate on the basic "Free-Vane" principle (see *Instruments*, Jan. 1932, page 9) but certain features of field adjustability have been added whereby sensitivity can be changed by means of a small screw driver to fit process lag and enable user to meet conditions not readily anticipated. Throttling range can be changed without removing chart or chart dial—without disturbing the operation of the controller or upsetting the operation or equilibrium of the process. Instrument can be changed from direct-acting to reverse-acting or vice versa, by turning the scale on the adjustment past the zero point.—*The Bristol Co., Waterbury, Conn.*

Multi-purpose Power Output Tube Tester

Demands for compactness in radio servicing equipment are met by new "Model 1501" multi-purpose power output tube tester said to combine the equivalent of ten separate units. For testing glass, glass-metal or metal tubes: Amplification tests, neon short test, separate diode tests, metered paper condenser tests (for short and open), electrolytic condenser leakage test, d-c. voltmeter and milliammeter, ohmmeter, a-c. voltmeter, decibel meter and impedance test. Furnished in quartered oak case with sloping panels for either portable or counter use.—*The Triplett Electrical Instrument Co., 326 Harmon Drive, Bluffton, Ohio.*

Redesigned Control Valve

Lighter yet stronger than the cast-iron construction which it supplants, and with greater resistance to shock and stresses, a new all-steel welded construction is the most evident change which has been made in the diaphragm-motor tops of "Evenaction" air-operated valves. Designated as "Motosteel Evenaction," new valves have a larger molded diaphragm which (in conjunction with formed impressions in top plate providing freer access of air pressure in starting) make the motor quicker-acting as well as more powerful. A longer, larger diameter spring gives greater initial compression and less hysteresis, hence more accurate response to commands of remote instrument. A ball-bearing, roller-bearing stem guide provides rolling action throughout entire stroke. Spring and spring adjusting nut, as well as other moving parts, are readily accessible by removing side plates. Valve position scale is combined with name plate. All parts are specially treated to resist corrosion.—*Taylor Instrument Companies, 95 Ames St., Rochester, N. Y.*

Refrigeration Calculator

Commercial refrigeration business usually requires compilation of refrigeration loads and selection of condensing units and coils. With new "Simplograph," average dealer and retail salesman are able to select proper refrigeration equipment (for various sizes of reach-in cabinets, walk-in coolers and various types of display cases which comprise majority of commercial refrigeration applications) in five steps: (1) Fixture temperature is subtracted from room temperature and this differential is set in a window on the front of the Simplograph; (2) referring to tables on device, a key number is selected under thickness of insulation and opposite size of fixture; (3) referring to tables, B.t.u. load per hour is obtained for this fixture; (4) turning device over, the figure nearest this load is set in the B.t.u. load window and a key in the form of a proper symbol between condensing room temperature and fixture temperature is secured; (5) referring to window under coils and units, look opposite this symbol and secure proper unit and coil required for fixture.—*Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

Fluid Metering Instruments

A complete line of indicating, recording, integrating and combination instruments of the mercury-and-float type, for use with orifices and other primary metering elements, in ranges from 1" water max. to 200" water max., now rounds out the maker's lines of tilting-manometer (uniform-chart) flowmeters and of electric flowmeters. Introduction of these models embodying a simple U-tube manometer is said to meet demand for inexpensive flowmeters for steam, water, air, gas and other industrial applications,

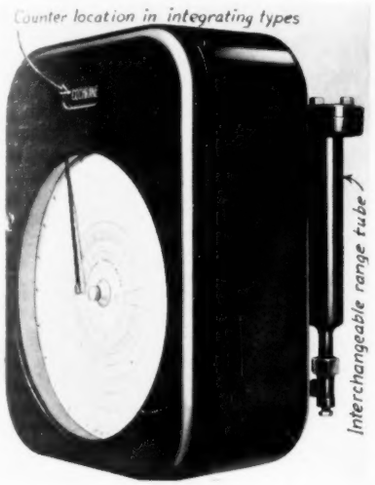


Fig. 1

particularly where maintenance must be minimized: simplicity and ease of access to all parts being emphasized. Charts of recorders are 12" diam.; dials of non-recording indicators are also 12" diam.; registers of integrators are direct-reading counters. *Clocks:* for recorders, spring-wound or electric with 24-hr. or 7-day chart rotation; for integrating models, 24-hr. spring-wound or electric, or 7-day electric. Other features are interchangeable manometer tubes to permit altering meter capacity, safeguards in both high- and low-pressure chambers to prevent loss of mercury, removable cover plate to permit cleaning of chambers, large float with high buoyancy, throttling bushing to dampen violent fluctuations in flow, pressure-tight bearing of hardened stainless steel, forged steel float chamber, adaptation to flush panel or rear mounting, and pressure and temperature records on same chart with flow. *Integrator* of new meter is positive and mechanical in operation (see Fig. 2). Movement of float is transmitted through a sector to the pinion on cam shaft. Cam is shaped to extract square root. A pin on integrator index arm rides against the cam,

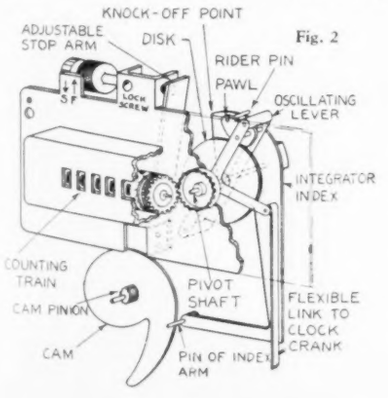
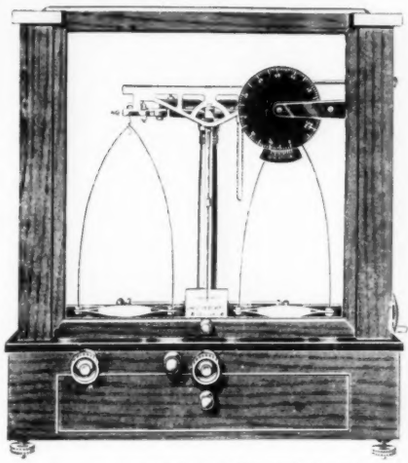


Fig. 2

in such manner that if cam is moved because of change in flow rate, index arm will assume a position corresponding to actual rate of flow. An oscillating lever is moved back and forth by a flexible link operated by a crank on the clock shaft. A pin attached to the pawl of this lever rides on the integrator index. When the pin reaches the knock-off point, the pawl engages with and advances a disk mounted on the first staff of the counting train, acting as a clutch or wedge to drive the disk forward. (On return stroke, pawl rides freely over disk.) This cycle is repeated every minute. Mechanism is so designed that no disturbance to pen position occurs through operation of the integrator, and it is said that slippage cannot occur.—*Cochrane Corp., Allegheny Ave. & 17th St., Philadelphia, Pa.*

Dial-reading "Chainomatic" Analytical Balance

Readings at eye level and minimal parallax are among advantages claimed for new "No. 415" Balance. Capacity is 200 g., sensitiveness 0.05 mg. with full load. Graduated dial and vernier read



0.1 mg. to 100 mg. Riders and fractional weights <100 mg. are thus rendered unnecessary and this, with newly patented device for altering chain length while beam is swinging and case closed, permits in many instances making determinations in one-fourth the time required by old methods. *Releasing mechanism:* beam arrest arms and beam being pivoted about a common axis, supporting points of arrest arms move through same arc as supporting points of beam, so that contact between edge and bearing always remains the same, and shifting of end bearings with consequent dulling of agate edges is thus precluded. *Movable Index:* Customary method of adjusting equilibrium of a balance has been by adjusting nut at end of beam, necessitating raising and lowering of front sash and not infrequently introducing an error owing to warmth of hand. "No. 415" Balance is equipped with a movable index ("Auto-Dex") controlled by a thumb wheel at left front of case, obviating necessity of touching adjusting nut, or of recording rest point, as rest point and zero point always coincide. Agate edges will last much longer, it is said, as it will be unnecessary to release balance so many times. During one year this may amount to 1000 times, it is said.—*Christian Becker, Inc., 92 Reade St., New York City.*

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Self-Synchronizing Motor

TYPE 769B
ACTUAL SIZE

Type 769B, the smallest self-synchronizing motor manufactured, is suitable for a wide variety of remote indication applications. Slight movements of sensitive elements such as diaphragms and Bourdon tubes may be instantly and accurately transmitted to duplicate or triplicate indicators.

Size—2⅜" diameter x 2⅜" long
Weight—10 ounces
Current—.16 amperes
Voltage—32V. A.C.—60 cycle
Power consumption—2 Watts
Heat Rise—15°C.
Peak Torque—40 Gram. Cm.
Maximum lag — approximately 1½ Degrees
Shaft Diameter—1/16"
Ball Bearing Equipped

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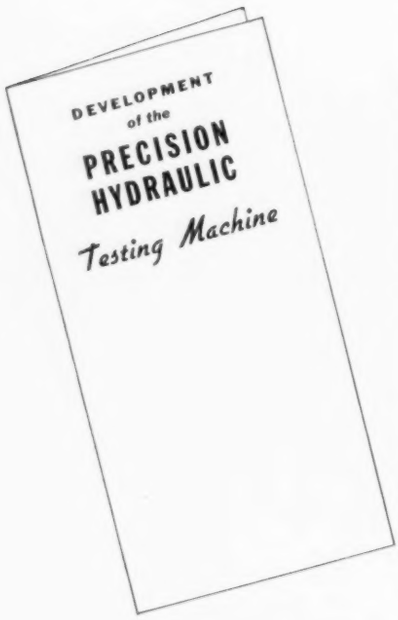

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Bubble Sextant

Designed from plans submitted by the Bureau of Aeronautics and Lt. Commander P. V. H. Weems, a new aircraft bubble sextant, with which the altitude of heavenly bodies may be measured without depending on a sea horizon, is intended primarily for use with aircraft, but is equally useful to surface vessels when stars are visible but no horizon, or when fog conceals horizon while permitting the sun's position to be seen. A self-contained artificial horizon in the form of a liquid bubble appears in the field of the sextant as a sharply defined circle to the center of which the heavenly body is brought to coincidence. The graduated arc, index bar and vernier of the regular sextant are replaced by a worm and gear mechanism operated by a knurled thumb wheel. The scale and vernier are replaced by a three-digit counter permitting reading altitude to a single minute of arc. Bubble is illuminated by a dry battery inside handle, the circuit passing through a two-way toggle switch, one position of which illuminates the altitude drums and the ground-glass record slate which is divided into two columns marked "Alt" and "Time." Instrument carries two movable moderating glasses for reducing

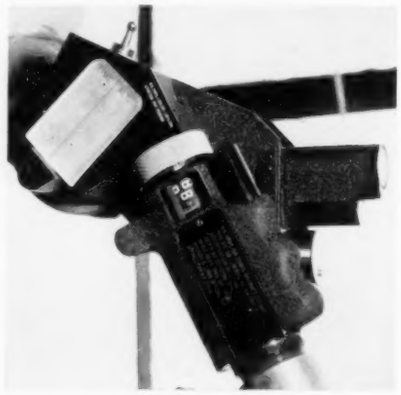


Fig. 1

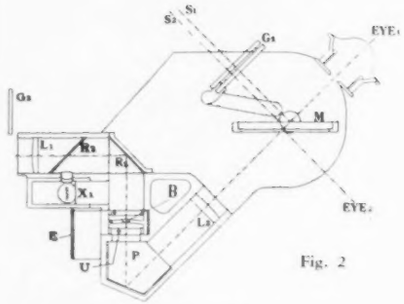


Fig. 2

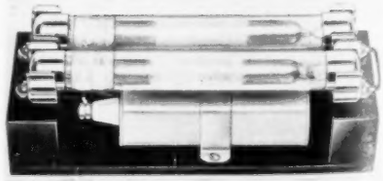
brightness of moon and sun to a comfortable degree for the eye. Bubble cell has a free-playing bubble composed of a mixture of volatile hydrocarbons. Bubble size may be changed quickly by rotating a milled button with directions engraved upon it. Entire bubble assembly is contained in a metal mounting forming a complete unit. *Operation (observing sun or moon)*—Moderating glass or glasses G_1 are put into position. Filter G_2 is dropped over lens L_1. Bubble is illuminated by throwing toggle switch and adjusting rheostat. The eye is placed in position EYE_1. Light from bubble passes through prism P and lens L_2, through index mirror M to EYE_1 which sees the bubble as if it were infinitely distant. Light from sun or moon passes along the path S_1 through moderating glasses G_1 to index mirror M from which it is reflected also to EYE_1. Now the image of the bubble and the image of the sun or moon will appear coincident only when mirror M is at the correct angle of rotation about an axis perpendicular to the paper. This rotation is accomplished by means of the knurled thumb wheel. When the images are in coincidence, the altitude may be taken from the counter drums. *For observing stars,* filter G_2 is also dropped over lens L_2 but moderating glasses G_1 are removed to their "out" positions. The eye now is placed at EYE_2. Light from the bubble traverses prism P and lens L_2, reaching the index mirror M whence it is reflected to EYE_2. Light from the star passes along path S_2 through index mirror M without change in direction to EYE_2. In this case also the star and the image of the bubble will appear infinitely distant. Coincidence is made as in the previous case. *For using the sea horizon,* filter G_2 is removed from in front of lens L_1; moderating glasses G_1 may be in or out, depending on the brightness of the heavenly body. In this case the lenses L_1 and L_2 constitute a unit power telescope presenting an infinitely distant image of the horizon to the eye either at EYE_1 or EYE_2. Coincidence with the horizon is made in the same manner by rotating the knurled thumb wheel.—*Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y.*

Electronic Circuit Protectors

A new line of gaseous discharge tubes has been developed for surge protection and arc suppression in highly inductive circuits, especially direct current. Principle: in a gaseous discharge tube no current flows until voltage applied is sufficient to ionize the gas, which then becomes a good conductor. Tubes are rated for use in 125-, 250- and 500-volt d-c. circuits and calibrated so that no load is placed upon the normal circuit. When surge potential (due to opening of a switch for instance) rises above normal, tube ionizes and shunts out the surge. Tubes are ordinarily placed in shunt with coil or magnet between switch and coil and reduce coil potential to normal within 0.010 to 0.1125 sec. after circuit is opened. Two current carrying capacities: Junior line with peak load value of 10 amps. and a Heavy Duty line with peak value of 100 amps.

A line of Arc Suppressors is also offered. This device is a combination of a surge protector tube and a capacitor. Furnished only in Heavy Duty type.—*Sundt Engineering Co., 4238 Lincoln Ave., Chicago, Ill.*

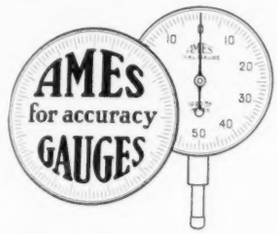
Surge Protector



Arc Suppressor

AMES GAUGES

of Solid Brass



Brass is used most commonly in the construction of gauges, instruments, clocks, etc., because it provides good bearing surfaces for staffs, is machined accurately, stamped and polished and plated easily and is tough and durable. Many parts of Ames Gauges are machined from solid brass. The cases are solid, thick-section brass tubing, as are the bezels. The movements are attached to thick plates of solid brass. The case stems are machined from brass rod, and the wheel support is stamped from sheet brass.

More reason why Ames Gauges exceed in durability and accuracy.

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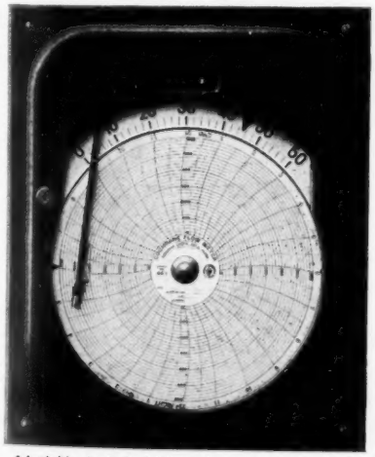

Adaptable to industrial service wherever the flow of steam, water or other liquids or gases is involved, Cochrane Flow Meters are sturdily built and extremely sensitive to variations in flow.

Recorders of both the Electric and the Mechanical models are guaranteed accurate within one-half of one per cent of absolute under full load.

Cochrane Electric Flow Meters operate on the super-accurate galvanometer null principle. They may be installed at any distance from the pipe line, facilitating central panel grouping.

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COCHRANE CORPORATION

Dept. INS-6

Allegheny Ave. & 17th St., Philadelphia, Pa.

Piezo-electric Oscilloscope Units

Deflecting element consists of a thin, narrow, twister bimorph element (0.030″ × 0.125″) cemented in Bakelite at one end; other end free to vibrate torsionally and carries a plane mirror about ⅛″ square. Leads are brought out through pins inserted in Bakelite base. This element is enclosed in an oil-tight brass housing consisting of a length of tube surmounted by a head of square stock provided with a lens-sealed window opposite mirror. Lens is plano-convex and has a focal length of 10″. This enables light from mirror to be brought to a focus without any additional optical part. Lenses of different focal lengths, or plane windows, can be supplied. The lens or window is tilted slightly downward so that any light reflected from its surface will not interfere with the light reflected from the mirror. Units are filled with oil which serves as a damping agent and also protects the crystal against physical shocks due to rough handling. Oscilloscope units are voltage-operated devices of high impedance, designed to cover frequency ranges of 1,000, 5,000 and 10,000 cycles. Over the specified frequency range the response is essentially constant for a fixed impressed voltage. Lowest impedance in each frequency range is about 30,000 ohms, so that when operated by an amplifier an ordinary general purpose triode may be used as a driver.

Type OS-1 (illustrated half actual size), for frequencies < 1,000 cycles, has sensitivity of the order of 0.001 radians per peak volt, which will produce a band width of 2″ at 10″ radius for an applied a-c. potential difference of 100 peak volts. Deflections are proportional to applied voltages; 30 to 50 volts r.m.s. will generally produce sufficient response. Sensitivity figure given is for room temperature. Temperature changes will cause variations in sensitivity (kept within 2 or 3 db by inserting in series with the unit a capacity whose impedance matches that of the crystal element: *e.g.*, a 0.004 mfd. capacitor).

Type OS-2 is for < 5,000 cycles. Band width due to a fixed impressed voltage is essentially constant throughout entire frequency range, and sensitivity is approx. one-quarter that of Type OS-1. A series capacity of 0.001 mfd. will generally be found satisfactory for minimizing temperature variations.

Type OS-3 is designed for applications where high fidelity is the most important consideration involved. Uniform band width < 10,000 cycles. Sensitivity about half that of the OS-2.

Illustration shows stand on which each unit may be mounted adjustably.—*The Brush Development Co., East 40th & Perkins Ave., Cleveland, Ohio.*

Do you know your vacuum?

Let the TRU-VAC gauge tell you—accurately—continuously. Records pressures from 0—10,000 microns. Invaluable in processes requiring dependable knowledge of vacuum conditions.

Its numerous advantages are outlined in our bulletin TV2, gladly sent upon request.

CONTINENTAL ELECTRIC CO.

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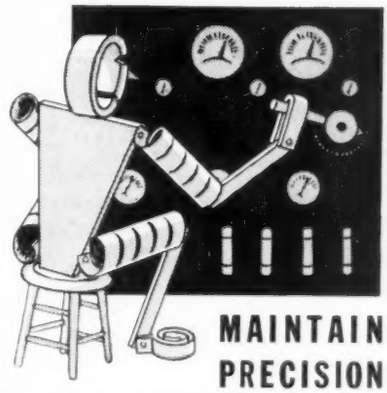
PHOTOCELLS VACUUM SWITCHES



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Ambient conditions cannot upset the precision of a temperature recording or controlling instrument if Truflex bimetal is on the job. For Truflex compensates for those conditions—keeps the instrument true.

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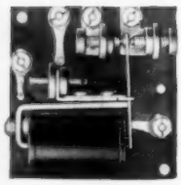
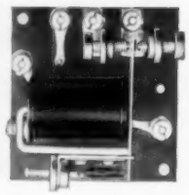
2 New D. C. Sensitive Relays



2C



1C

SENSITIVE
14 Milliwatts for positive operation.

ADJUSTABLE
Pull up—drop out—speed.

DROP OUT
From 50 to 85% of pull.

CONTACTS
Fine silver—1½ amps 110 V. A.C.

RANGE
.0005 V. 25 amps -to- 20 V. .00065 amps.

FEATURES
1C—Wide contact separation.
2C—Speed .001 seconds.

RUGGED
Some customers report 4 years continuous satisfactory operation.

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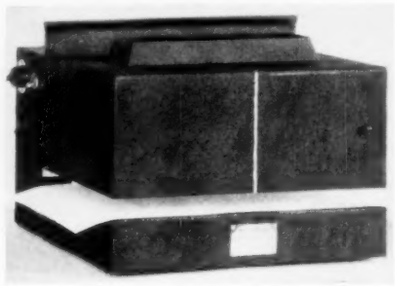
Paper Inspection Device

Developed primarily for detecting fuzz on paper surfaces, new "Fuzz Detector" can be used for revealing other surface imperfections and characteristics, under comparative conditions of viewing and illumination. With its use, paper machine



operators or paper tester can readily inspect the condition of the paper surface for such defects as fuzz, wrinkles, cockles, roughness or grain and indentations; also scuffed, picked and streaked surfaces, felt and wire marks, rust from dryer rolls, etc. Illumination consists of two 100-watt lamps contained in a suitable housing, adjustable to proper angle over the 12″ × 15″ viewing table on which material to be observed is placed. An adjustable slit is provided between light source and viewing table. Over viewing table is placed a metal housing (designed to eliminate glare and exclude external light), provided with an opening through which operator views sample and with a door through which hand can be inserted to facilitate further inspection and to rub paper surface to ascertain tendency to fuzz. By a single setting of light source and slit opening, materials of widely varying thicknesses can be examined, such as tissues, bonds and bristols. Materials $>\frac{1}{8}$″ thick require a slight adjustment of illuminating device. The presently designed instrument will accommodate thicknesses <1″.—*Hammermill Paper Co., Erie, Pa.*

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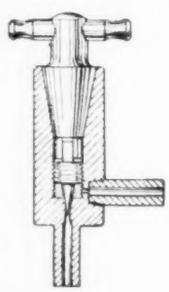

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The U. G. I. Nitric Oxide Recorder*

By W. E. STACKHOUSE

The United Gas Improvement Company, Philadelphia, Pa.

ABSTRACT BY AUTHOR

An apparatus has been developed for continuously recording the quantity of nitric oxide in manufactured gas. The nitric oxide is oxidized in the gas phase and absorbed in Griess-Ilosvay reagent, which develops a color ranging from pink to red. The color intensity is measured by a photocell circuit and a potentiometer recorder calibrated to read directly in terms of nitric oxide concentration.

I. NATURE OF PROBLEM

FOR several years the Department of Research and Tests of The United Gas Improvement Company has been engaged in a study of the problems resulting from the presence in manufactured gas of particles of gum. The effect of gum is evident in gas pilot stoppages and in malfunctioning of water heaters, of gas refrigerators and of other gas appliances in which the gas flows through small openings. Deposits occur also on the valves of governors, meters and compressors.

Investigations[1, 2, 3] have shown that the gum is formed from the reaction of small amounts of nitric oxide and oxygen with any of a number of organic compounds in the gas. The reaction occurs in the vapor phase and results in the formation of submicroscopic particles which remain dispersed in the gas for long periods. In passage through small needle valves and orifices these particles deposit in the openings and restrict the gas flow.

The source of NO in the gas is products of combustion. In carburetted water gas its presence is due to incomplete purging of the water-gas sets, leaking blast valves, etc., and in coke oven or coal gas to cracks in the settings and consequent leakage of the products of combustion into the make gas because of the normal operation of the ovens at less than atmospheric pressure.

Although NO occurs in the gas in relatively small amounts, a concentration of the order of one part in 35 million (0.0286 parts per million) will cause trouble due to formation of vapor-phase gum in the gas. Tests indicate that to avoid trouble from vapor-phase gum the NO should be kept below one part per 350 million. While it is not the purpose of this article to discuss the relationship of NO and gum, it should be noted that in situations where all of the NO has combined with gum formers it is possible for the gas to contain no NO yet have a gum content sufficient to cause trouble.

The unit for expression of NO concentration that has proven most convenient is "grams of NO per million cubic feet of gas, observed." This is a hybrid unit but allows expression of concentrations usually encountered, in integers and not small decimals. One gram per million cubic feet is equivalent to one part in 35.4 million.

Obviously the determination of such low concentrations presents a much greater problem than the methods for determining the other usual impurities in the gas, such as ammonia and hydrogen sulphide.

*Patent applied for.

[1]Ward, Jordan & Fulweiler. *Industrial & Engineering Chemistry*, Vol. 24, 1932, pages 969 & 1283; Vol. 25, 1933, page 1224.

[2]Jordan, Ward & Fulweiler. *Industrial & Engineering Chemistry*, Vol. 26, 1934, pages 947 & 1028; Vol. 27, 1935, page 1180.

[3]Fulweiler. *Proceedings American Gas Association*, 1931, page 771; 1932, page 838; 1933, page 829; 1934, page 954; also *American Gas Journal*, Vol. 140, 1934, page 25.

II. ANALYTICAL METHOD

The analytical method was developed after extensive study of the various methods reported in the literature.[4] It consists essentially of oxidizing the NO contained in a known volume of gas and absorbing the resultant product in Griess-Ilosvay reagent. A colorimetric comparison of the resultant test solution with color standards yields a figure which represents a definite concentration of NO in the solution. Knowing this and the gas volume used during the test, the concentration of NO in the gas is readily calculated as grams of NO per million cubic feet, observed. Conversion to actual grams is effected by use of multipliers for the observed values. These conversion factors have values ranging from 2.9 for 1.0 gram observed to 2.3 for 15 grams observed. These values have been obtained by determinations of known NO concentrations in synthetic gas-NO mixtures. However, for usual plant control work, the "observed" values are used directly.

The chemical test as devised was intended for running "spot" tests, lasting from perhaps 15 minutes up to possibly 2 hours, depending upon the concentration, obtaining the average concentration during the test period.

Because of the nature of the methods of gas manufacture, variations in the concentration of NO in the gas are likely to occur from time to time. As a high NO concentration over a short period of time may cause as much trouble as low concentrations over long periods, a device giving continuous records of NO concentration was essential for study and control of the problem. The advantages of such a recorder, showing the hour-to-hour variations throughout the day as against spot test readings once or twice a day, are obvious.

III. THE NITRIC OXIDE RECORDER

The form of the Nitric Oxide Recorder is shown in Fig. 1. At the right is the chemical cabinet in which the gas being tested is specially purified for test purposes, as described later. The NO is oxidized and the reaction product absorbed in the Griess-Ilosvay solution, yielding a pink color the depth of which is a function of the oxidized NO. This colored solution is analyzed for color intensity by means of Weston "Photronic" photocells contained in the lower compartment of the chemical cabinet.

The recording potentiometer shown at the left measures the potential drop across a fixed resistance. This resistor forms part of a resistance network into which is fed the output of the Photronic cells. The calibration of the potentiometer is in terms of NO concentration directly.

The recorder has been designed to operate continuously for a week, at the end of which time the solution reser-

[4]Fulweiler. *American Gas Journal*, Vol. 142, 1935, page 27.

voirs are refilled and certain portions of the glassware cleaned.

Chemically, the recorder and manual (or "spot") test are identical. The difference lies in the method of determining the color intensity of the test solution. In the manual apparatus the test solution is matched by eye with known color standards, whereas in the recorder the test solution is passed through a comparison tube continuously and the color intensity determined in terms of light transmission as measured by a pair of Photronic cells.

In the chemical operation of the recorder, the gas to be tested is passed through a small reciprocating pump driven by a self-starting induction motor. The pump is used for boosting the pressure of the gas to 20″ water column, a pressure sufficient to overcome the pressure drops of the scrubbers. The pump passes 1.2 ft.^{3}/hr. of gas and, of this, 0.4 ft.^{3}/hr. is normally used in the test, the surplus gas bubbling through the pressure regulating tube and then to the purge line.

The gas for test then passes through a Milligan-type gas-washing bottle containing 25% potassium hydroxide solution, which removes hydrogen sulphide. The potassium hydroxide scrubber incidentally removes carbon dioxide and the bulk of the water vapor. It is necessary in the test to remove completely all traces of hydrogen sulphide to prevent bleaching and "off colors" of the test solution.

From the potassium hydroxide scrubber the gas passes through a scrubber containing a 10% solution of maleic anhydride in isoamyl alcohol for removal of all those hydrocarbons that catalyze the oxidation of NO and formation of vapor-phase gum. From the isoamyl alcohol scrubber the gas passes through a differential flowmeter for indication of the gas rate.

At the outlet of the gas flowmeter, commercial oxygen, metered by a differential meter, and butylene (containing butadiene) fed at a controlled rate are mixed with the gas being tested and passed into a reaction bottle of such size that with 1.5 minutes time of contact the NO is catalytically oxidized by the excess of oxygen in the presence of butadiene.

All the hydrocarbon catalysts are removed in the maleic anhydride-isoamyl alcohol scrubber for the reason that some of them catalyze the formation of vapor-phase gum from the oxidized NO. The formation of gum during the analysis would cause a lowered recovery of NO. It is necessary, however, to have present a catalyst that will accelerate the oxidation of the NO. For this purpose the butadiene is added, and complete oxidation of the NO is obtained in a contact time of 1.5 minutes. Butadiene would also catalyze the formation of vapor-phase gum from the oxidized NO, but there is an induction period of approximately 3 minutes before the rate of that reaction becomes appreciable, and in the meantime the oxidized NO has been absorbed in the Griess-Ilosvay reagent.

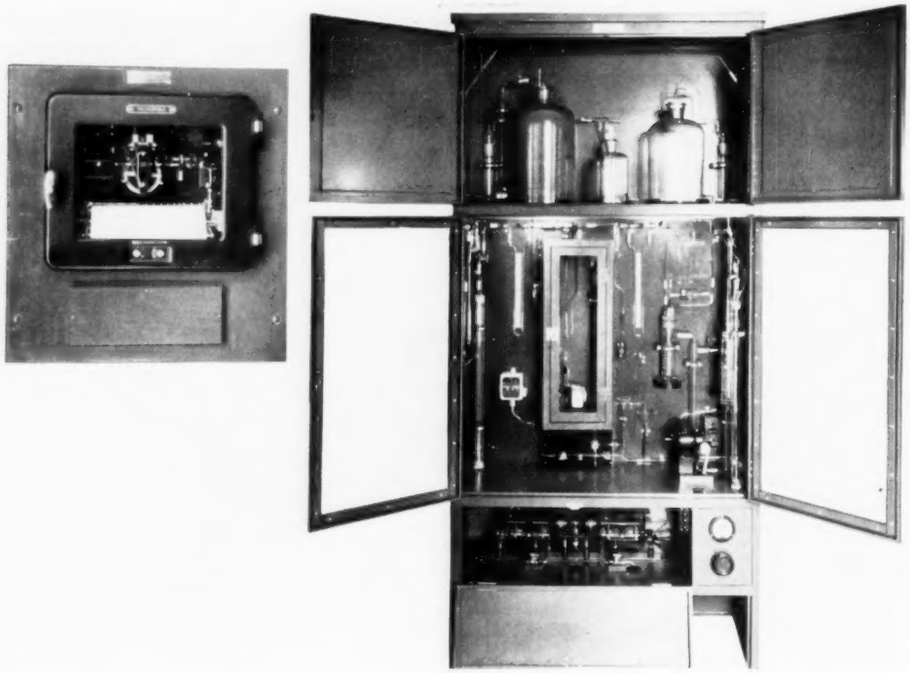


Fig. 1

From the outlet of the reaction bottle, the gas-oxygen mixture enters an absorption tower, arranged for counter-current gas-liquid flows. The tower is packed with solid glass beads, and the design is such that with the NO concentrations to be determined by the recorder, an absorption efficiency of 99% or better is obtained.

The Griess-Ilosvay reagent used in the recorders to determine the amount of oxidized NO is composed of acetic acid, alpha naphthylamine and sulphanilic acid in nitrite-free distilled water. The reagent when prepared is water-clear but forms a purple-red azo dye in the presence of nitrites. This reagent was originally developed for determining nitrites in water analysis and is more sensitive and easier to use than any of the others proposed for nitrite determination.

The Griess-Ilosvay reagent, properly diluted, is fed from the storage reservoir to the standard or blank comparison cell and from this cell to a Soxhlet-type syphon which "trips" at regular intervals (approximately every 20 minutes with the usual Griess solution rate) discharging directly into the top of the absorption tower. The

discharge period of the Soxhlet syphon tube is so short and the volume delivered is of such size that a nearly unbroken column of solution travels down the absorption tower, in this way wetting all the beads. This type of solution feed accounts for the nearly complete absorption of the oxidized nitric oxide passing up through the tower. From the tower the solution enters the test comparison cell.

The color of the test solution, when present by reason of the oxidized NO, causes a difference in light energy reaching the test Photronic cell and a change in current output of the latter, unbalancing the potentials in the resistance network. This unbalance is measured by the recording potentiometer. The relation between potential unbalance and color intensity is determined by the use of color standards. The previous calibration of the instrument with color standards allows the color intensity to be recorded directly in terms of NO concentration.

The light source is a high-intensity, low-voltage, tungsten-filament lamp. By operating the lamp at less than rated voltage, after proper aging, constant light intensity is obtained for five weeks, after which a new aged lamp is installed. The lamp is operated directly on 60-cycle current, using a saturated core-type voltage regulator.

Mounted on either side of the lamp, bi-convex lenses render parallel the light entering the liquid comparison cells. The comparison cells are Pyrex cylinders having Pyrex windows fused directly to the cell body. The cell windows are optical grade Pyrex, causing no distortion of the light entering the cells.

The photocells are mounted on the comparison cell holders, being properly screened, and receive the transmitted light from the comparison cells. The output of the photocells feeds into a resistance bridge network arranged in such way as to develop a potential across one arm of the bridge with change of color in the test comparison cell. The potential difference across this arm is measured by a potentiometer strip-chart recorder. The special scale of the recorder is semi-logarithmic, giving the advantage of reading the lower concentrations with rather large deflections, since it is of more interest to differentiate 0.2 and 0.3 grams per million cubic feet than, say, 8.0 and 8.1 grams. The recorders are furnished with specially printed chart rolls. The standard range of the recorders is 0 to 15 grams of NO per million cubic feet observed, but they can be operated directly with any multiplier up to 30×, giving a total range of 450 grams. This is accomplished by suitable adjustment of the gas and oxygen rates.

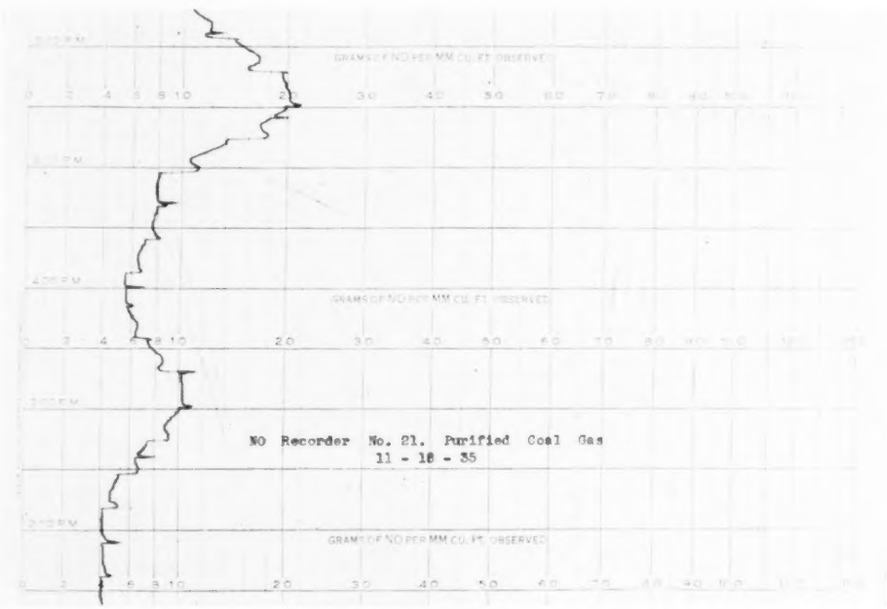


Fig. 2

The section of chart illustrated in Fig. 2 is typical of the records obtained and shows that average values as obtained by means of the spot testing apparatus during any period of time may be misleading and should be interpreted only in comparison with variations as indicated by recorder results.

Constant flow of solutions in the recorder has been accomplished by using Mariotte-type constant-head solution reservoirs. These deliver solutions to the control capillaries at constant hydrostatic heads regardless of the solution levels in the reservoirs.

Constant rate of flow of the Griess reagent is required regardless of changes of ambient temperature of the recorder. This is necessary because the calibration of the recorder is dependent upon the rate of Griess solution flow, response of the photocells to definite color standards and the gas rate. This constant flow of Griess solution is accomplished by using the above-mentioned constant-head reservoir and having the control capillary mounted inside a thermostated cubicle which is maintained at a temperature of 92°F. This constant-temperature cubicle is necessary for maintaining the temperature of the reaction bottle and absorption tower, 92°F. being the optimum temperature for the oxidation of the NO and absorption of the product in the Griess solution.

Minor variations in the rate of flow of the potassium hydroxide solution and of the maleic anhydride-isoamyl alcohol solution with changes in ambient temperature do not affect the accuracy of the recorder. Furthermore, these variations are slight because the recorders are intended for use in normally occupied rooms having temperatures in the usual range, 65 to 95°F. A length of stainless-steel capillary is used for the control of the potassium hydroxide solution, since glass capillary is so quickly enlarged by the caustic solution.

The butylene with butadiene is obtained liquefied in cylinders. At 70°F. the vapor pressure is 40 lbs./in.^{2} gage, and it is necessary to reduce this pressure to approximately 6″ water column and control with a stopcock the butylene feed rate, which is 0.01 ft.^{3}/hr. (4.7 ml/min.). In the first recorders the butylene was expanded by a relay-solenoid valve system, but the recorders are now equipped with pressure regulators of the type used with the liquefied petroleum gases.

Thirteen recorders have been made and sold by The United Gas Improvement Co. The companies using them are finding them of great service in the study of the problem of controlling nitric oxide in manufactured gas. Arrangements have been completed whereby these recorders will be made commercially available in the future.

The New Dry Batteries for Instruments

By H. E. LAWSON
Research Engineer, Burgess Battery Co., Freeport, Ill.

WHILE the development of instruments that formerly utilized dry cells seems generally towards the use of the more economical power of the transmission lines, the dry battery industry is still increasing in size. This is due partly to the growing popularity of new uses which demand a current supply to the delivery of which dry batteries are ideall ysuited. Pure direct current in small, portable packages is still most satisfactorily obtained from this source. Aside from the current characteristics, low cost is an important factor.

The service required of cells in present-day Instrumentation equipment and research apparatus can be divided into five general classes, as follows:

(1) Maintenance of constant emf.
(2) Generation of light.
(3) Generation of heat.
(4) Generation of motion.
(5) Generation of sound.

Ohmmeters and potentiometers and various special instruments developed from them are typical examples of the first class; optical pyrometers and theodolytes, of the second; various small motors, vibrators and solenoids in relays comprise the third; caponizers which operate by means of a heated wire are typical of the fourth group; and the various alarms the fifth. The device and the power supply appear to be dependent upon each other, the demand bringing about improvements in the cells and these more efficient cells making further uses practical.

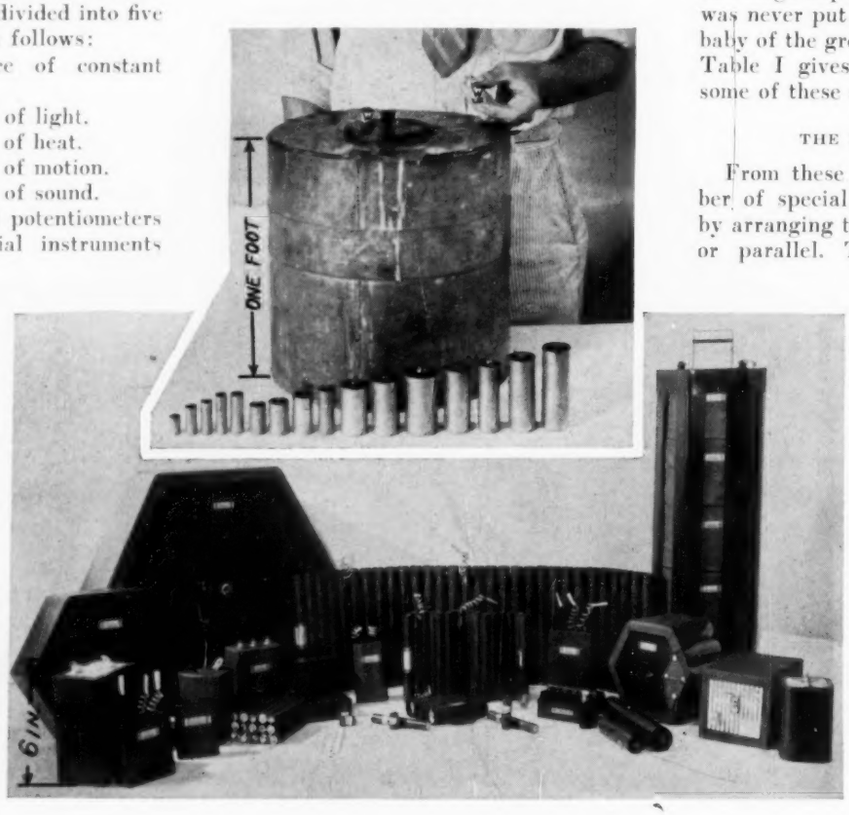


Fig. 1. The various sizes of cells manufactured by the Burgess Battery Co. (The large one is not commercial.)

Space will not permit the description or even enumeration of all the various uses that present day dry batteries must successfully meet. The characteristics of a few members in a group of newer batteries now being constructed for special instrument and laboratory use will be briefly touched upon in this article as a guide for the selection of the most satisfactory ones. It often is found that marked improvements in the performance of many instruments will be obtained by the wise selection of the power supply.

Efforts were made in the past towards the production of more powerful cells, and these occasionally met with some success, but it was not until recent discoveries were made relative to the internal economy of this type of cell that the economical production of reliable and uniform ones was made possible. There are relatively few individual sizes of cells from which the new batteries are made. The open-circuit voltage of each is in the neighborhood of 1.6. Fig. 1 shows the relative sizes of most of the cells manufactured by the Burgess Battery Co. with one large experimental one which was never put on the market. The baby of the group is marked "W." Table I gives the dimensions of some of these cells.

THE BATTERIES

From these cells a great number of special batteries are built by arranging them either in series or parallel. The characteristics shown in the graphs that follow will, of course, hold for the batteries when account is taken of the number of cells in series or parallel. The shelf life and capacity will not vary greatly, but the voltage and internal resistance will be multiplied by the number of cells in series. The internal resistance is divided by the number in parallel, and the voltage unaffected by such number.

Fig. 2. Some of the special batteries being manufactured for use in instruments.

TABLE I—CELL DIMENSIONS

	D (inches)	L (inches)	Weight (gms.)
W	.5	.97	8
X	.5	1.34	11
Z	.5	1.875	14
B	.75	2.125	34
T	1.00	3.19	100
F	1.25	3.437	156

Table II gives the dimensions and voltages of a few of those batteries that are at present most popular. Some of these batteries appear in the group shown in Fig. 2.

Many technicians are still under the impression that the so-called "shelf life" or storage life of a dry cell is in some way proportional to its size, and that the smaller units are particularly poor in this respect. This property is a greatly misunderstood one. There are at least three types of "shelf life":

(1) Drop in voltage on open circuit.

(2) Drop in capacity between fresh and delayed discharge.

(3) Drop in capacity when cell is stored between two or more periods of discharge.

These three types are illustrated in Fig. 3 for two of these cells, small and large.

CAPACITY

It is impossible to state definitely what service can be expected from a cell when used under the great range of conditions of current drain, temperature, and degree of intermittence of discharge to which it may be subjected.

The curves in Fig. 4 will, it is hoped, give sufficient information to enable the technician to select the most likely battery for his particular service, assuming that the shelf lives of all batteries listed are of the same order.

INTERNAL RESISTANCE

For many instrument uses the internal resistance of the cell or battery being used is of considerable importance. Of the many methods that have been proposed for measuring internal resistance, perhaps the simplest one giving reasonably accurate results is that in which an alternating current bridge is employed. Two cells of the same emf. are connected in opposition and the readings made. The resistances of the wires in the circuit can be corrected for, and the resistance of the two cells divided by two. When a cell is to be measured under load, the cells are connected as above. The two negatives are connected to opposite ends of a slide wire rheostat and the positive to the slide in such a way that when the slide is set in the middle both cells are discharged at the same rate. This slide is then so adjusted that the voltages of the two cells cancel out and no direct current is passed through the bridge. The usual calculations are carried out for finding the resistance of the cells when that of the coils in parallel to them are known.

Figs. 5 and 6 show the relationships of internal resistance to drain and closed circuit voltage during discharge for several of the special cells referred to here.

TABLE II—MISCELLANEOUS DATA

RIBBON "B" BATTERIES

Designation	*Terminals*	*Weight*	*Rolled Max. Dia.*	*Flat Dimensions*
B30F	—, +22½, +45 V	2 lbs. 6 oz.	3 5/8"	8¼"x7¾"x1 13/16"
Z30F	—, +22½, +45 V	1 lb. 1 oz.	2 5/16"	6" x6½"x1 13/16"
X30F	—, +22½, +45 V	12 oz.	2 5/16"	6" x5" x1 13/16"
W30F	—, +22½, +45 V	8 oz.	2 5/16"	6" x3 5/8"x1 13/16"

REGULAR MIDGET "B" BATTERIES

Z30P	—, +22½, +45 V	1 lb. 6 oz.	1¾"x2 13/16"x5 1/16"
X30FL	—, +22½, +45 V	13½ oz.	1 5/16"x3 1/16"x4 1/16"
W30FL	—, +22½, +45 V	8½ oz.	1 5/16"x2 13/16"x3 1/16"

PORTABLE 3 AND 4½ VOLT "A" BATTERIES

			D	*W*	*H(body)*	*H.O.A.*
B2FL	—, +3	3¾ oz.	13/16"	1 5/8"	2 5/16"	3"
B3FL	—, +4½	6 oz.	1 1/16"	2 7/16"	2 13/16"	2 13/16"
T3FL	—, +3	8 oz.	1 1/16"	2 7/16"	2 7/16"	4 1/16"
T2FL	—, +4½	15 oz.	1 1/16"	3 1/8"	3 1/8"	3 1/16"
F2 (1025)	—, +3	16 oz.	1 5/16"	2 5/16"	4"	4 3/8"
2F2BP	—, +3	1 lb. 12 oz.	1 1/4"	5 3/8"	4 1/8"	4 3/8"
2F3R	—, +4½	2 lbs. 5 oz.	1 1/2"	3 7/8"	—	8 3/4"
4FH	—, +1½	1 lb. 5½ oz.	2 5/8"	2 5/8"	3 7/8"	4 7/16"

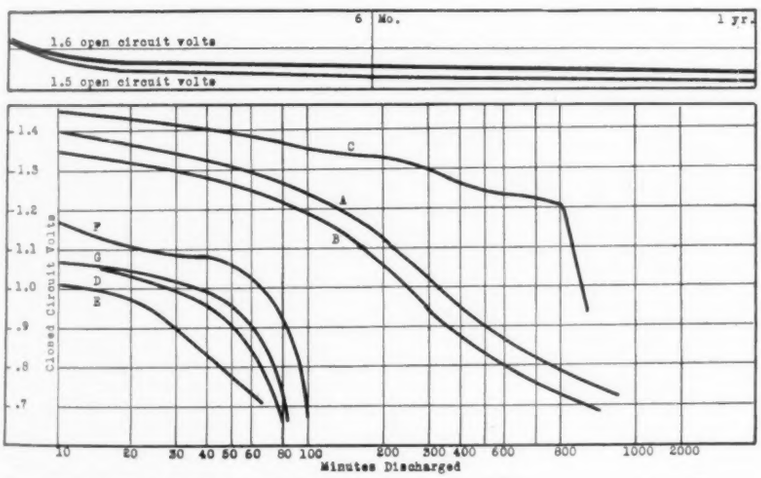


Fig. 3. "Shelf Life."

Upper Panel - Size F & Z cells - Open Circuit Voltage vs. Age of Cell.
Lower Panel - Discharge Curves
Curve A - Size F cell discharged continuously on 4 Ohms when fresh
Curve B - Size F cell discharged continuously on 4 Ohms when 6 months old.
Curve C - Size F cell discharged 5 minutes per day on 4 Ohms when fresh
Curve D - Size Z cell discharged continuously on 4 Ohms when fresh
Curve E - Size Z cell discharged continuously on 4 Ohms when 6 months old.
Curve F - Size F cell discharged 5 minutes per day on 4 Ohms when fresh
Curve G - Size Z cell discharged 5 minutes per day on 4 Ohms when 6 months old.

Fig. 3

Fig. 4. Capacity in hours of service as related to drain in mils.

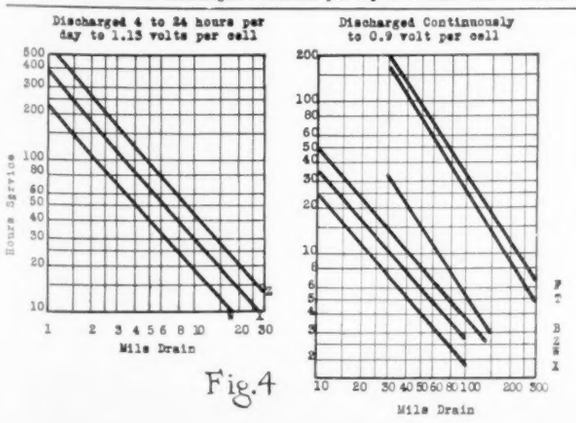

Discharged 4 to 24 hours per day to 1.15 volts per cell
Discharged Continuously to 0.9 volt per cell
Hours Service
Mils Drain
Mils Drain

Fig. 4

Fig. 5. Relation between current drain and initial internal resistance of cell.

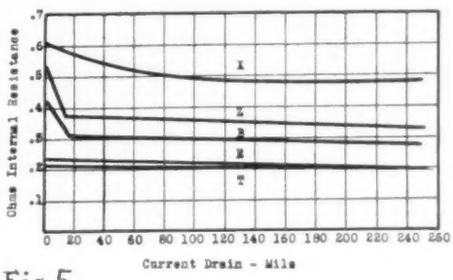
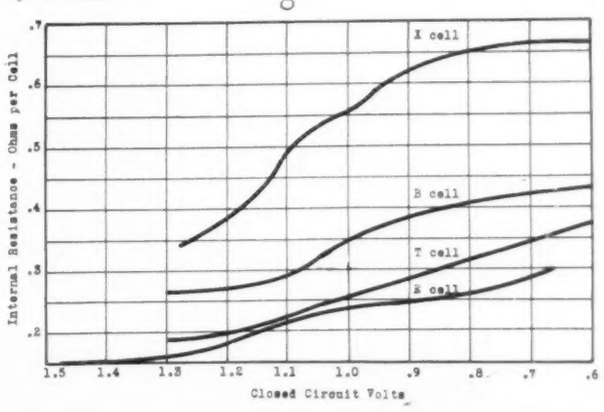


Fig. 5

Fig. 6. Relation between closed circuit volts on 4 ohms continuous discharge and internal resistance of cells.

Fig. 6



Cathode-ray Oscillograph Auxiliaries

Twelfth part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in the July 1936 issue.

By RALPH R. BATCHER

Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.

TRANSLATING INSTRUMENTS AND DEFLECTION ACCESSORIES.

(Concluded)

PIEZOELECTRIC UNITS.[16-22]

When a plate, with its faces plane and parallel, is cut from one of certain crystals (such as quartz, Rochelle salts, etc.) so that the plane of the plate is perpendicular to an electric axis of the crystal, it possesses the property of liberating electricity at these faces when subjected to a strain. The charge between the faces is exactly proportional to the force applied, from extremely feeble pressures up to strains approaching the overload point of the crystal. This effect, discovered by Curie half a century ago, was mostly a tool of pure science until the cathode-ray oscillograph permitted its wide employment

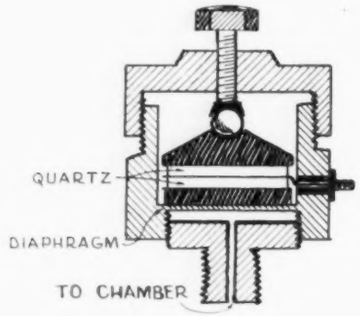


Fig. 5

in various industries. Several forms of devices are commercially available, for picking up feeble sound vibrations, for measuring explosion pressures in guns, and for all intermediate pressure and vibration applications. Technical literature abounds with references to numerous special forms of piezoelectric units. The popularity of these units is chiefly due to the remarkable constancy of calibration which crystals possess. It may be asserted that when a crystal is maintained at constant temperature its pressure-emf. characteristic does not vary more than one part in ten million. (The temperature coefficient, by the way, is simply the effect of dimensional change.)

Some types of piezoelectric units will generate high potentials when warped (several hundred volts) and can be used without amplification if the deflection plate circuit impedance is high enough. The crystal gives the greatest output when working into an open circuit. The deflection plate load, especially with gas-focused tubes, and tubes where the plates are shunted with a leak resistor, will reduce this potential appreciably so that for best results a high-impedance high-mu electron tube should be used to couple the crystal to the deflection plates.

Fig. 5 represents a pressure translation device designed by Watanabe[23] for studies of combustion engine cylinder pressures, using the piezoelectric principles. When connected to a cylinder the gas pressure is applied to the diaphragm so that a force is applied to a pair of quartz crystals which are under a certain initial pressure due to the adjusting screw. A connection is made to a metal foil between the crystals, which are so cut and oriented that the potentials generated in each do not oppose each other. Details of the design, calibration and sample oscillograms are given in the original account (which is in English). See also references 24, 25 and 26.

Obata has designed a similar unit[27] in which, however, the piezoelectric element is replaced by a small condenser. The capacity of the plates is altered as one is moved by the pressure being studied. The same investigator has used such a device in an unusual application: checking the quality and strength of brick by analyzing the sounds given out when they are struck.

Fig. 6

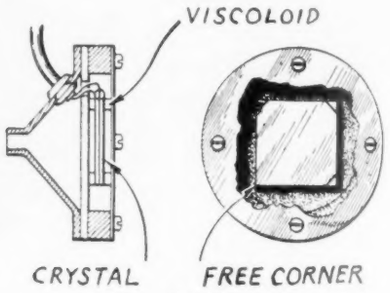


Fig. 7

A recent commercial application of the piezoelectric principle (RCA Mfg. Co.) is shown in Fig. 6. This unit is especially adapted for the study of vibration with a cathode-ray oscillograph. As described by the manufacturer, "the back of this unit is threaded for the insertion of a prodding rod or it may be clamped directly to any mechanism. It is not responsive to sound vibrations transmitted through the medium of the air but must be mechanically connected in order to operate. If the grid circuit of a linear amplifier tube is connected across the electrodes fastened to the two faces of the crystal, the plate current of this tube will vary in accordance with the charge. Thus the output of this tube is an amplified electrical representation of the mechanical vibration of

[16]Watson & Keys. Piezoelectric Studies on Combustion Engines. *Canadian Journal of Research*, Vol. 6, 1931, pages 322-325.

[17]Kluge & Linckh. Piezoelectric Measurements. *Zeitschrift Vereines Deutscher Ingenieure*, Vol. 73, 1929, pages 1311-1315.

[18]Keys. The Cathode-ray Oscillograph in the Measurement of Explosion Pressures, etc. *Journal Franklin Institute*, Vol. 196, 1923, pages 577-591.

[19]Webster. Piezoelectric Gage and Amplifier. *Journal Franklin Institute*, Vol. 211, 1931, pages 607-615.

[20]Ervin. Piezoelectric Gage for ballistic studies. *Journal Franklin Institute*, Vol. 213, 1932, pages 503-514.

[21]Keys. Piezoelectric Method of Measuring Explosions. *Philosophical Magazine*, Vol. 42, 1921, pages 473-488.

[22]Anon. Rolling Mill Measurement (Piezoelectric). *Archiv für technisches Messen*, Vol. 3, Dec. 1933, pages T163-164.

[23]Watanabe. A Study of Impact Test by Cathode-ray Oscillograph. *Scientific Papers Institute of Physical & Chemical Research*, Vol. 12, 1929, pages 99-112.

[24]Serruys. Piezoelectric Observations on Engine Knock. *Comptes Rendus*, Vol. 197, 1933, pages 1296-1298.

[25]Kaufmann. Oil Pressure Indicators. *Archiv für technisches Messen*, Vol. 1, July 1931, page T7.

[26]Gehlen. Measurement of Oscillating Pressures. *Archiv für technisches Messen*, Vol. 1, Dec. 1931, pages T81-83.

[27]Obata. Tests on Brick by Means of Sound. *Journal Franklin Institute*, Vol. 203, 1927, pages 647-659.

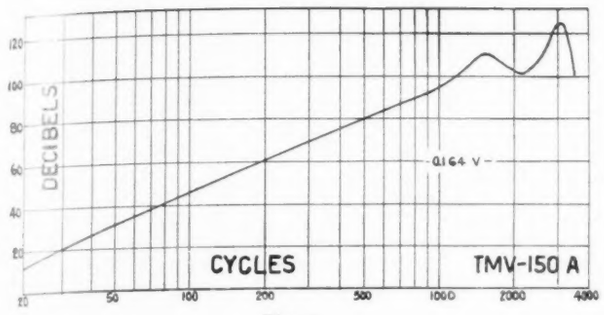


Fig. 8

the crystal. In order that severe vibration will not break the crystal the unit is so constructed as to be inertia operated (Fig. 7): the square crystal is mounted to the case from three corners, the fourth corner being free to vibrate. When the entire case is moved this corner of the crystal, due to its inertia, attempts to remain stationary, and the crystal is thus bent. With this type of operation the sensitivity of the crystal increases approximately as a square law with an increase of frequency of vibration, up to the natural frequency of the crystal which is about 2,950 cycles per second. This is a benefit as high frequency vibrations are usually much less in amplitude than low frequency vibrations. At any one frequency the output is directly proportional to the amplitude of vibration up to the overload point of the crystal."

The square-law relation between frequency and output is shown graphically in Fig. 8. This curve gives the output potential at various frequencies for a 0.001" displacement. The reference level (0 db.) is 0.164 millivolts. For many tests pickup units of a similar type can be adapted from a crystal type radio head set unit. In one series of tests one of the latter units was found sensitive to the vibrations of a small motor (to which it was clamped) after being conditioned by carefully cutting a small hole in the center of the receiver cap and cementing a bearing ball (about 3/16" diameter) to the center of the cone. Such units must be experimentally calibrated as to frequency.

PHOTOGRAPHIC RECORDING OF OSCILLOGRAMS[1-4]

While for many tests a visual inspection of an oscillogram is satisfactory, it frequently becomes necessary to make permanent records of certain types for additional analysis. The easiest method, insofar as additional equipment is concerned, is a pencilled tracing, as outlined in the December 1935 article. In the case of intricate patterns which vary rapidly or are produced by transients, photographic recording is essential. Methods used for this are (in the order of complexity):

1, Making a contact print by pressing a film or piece of sensitive paper against the end of the tube. In some tubes, equipped with fluorescent screens that are unusually actinic, blueprint paper can be used when the diagram is steady over periods of a minute or more.

2. Taking a photograph of the oscillogram with a camera.

3. Obtaining photographs with a moving film camera.

4. Inserting sensitive paper or film within the cathode ray tube, in a position where the photosensitive surface intercepts the electron stream.[5] In this case a special tube must be used which can be opened up for the insertion of new films. Vacuum pumping apparatus must be permanently connected to permit re-exhaustion after each film replacement. A well-known example of a cathode-ray tube built on this principle is that of Tinsley & Co., London, built after designs by Wood (Fig. 1).[6,7]

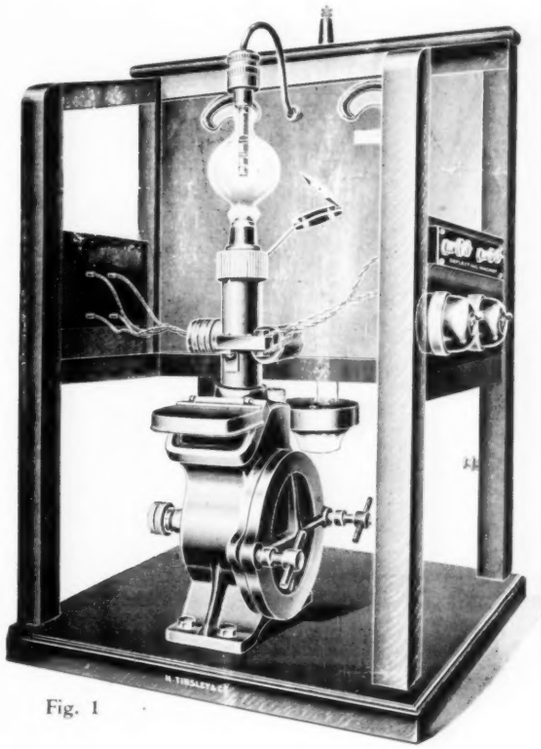


Fig. 1

CONTACT PRINTS[8, 9]

The sharpness of a contact print depends upon the careful application of the film or paper to the end of the tube. It should be held firmly in place in a manner that will minimize the "ruffles" that appear at the edges.

To reduce the errors due to "ruffling" an improvement has been made in the Western Electric 224C tube, by providing a screen with a contour that is a section of a cylinder instead of a section of a sphere. Such a shape withstands the atmospheric pressure, due to the arch effect, and a flat film can be held firmly and closely against the glass without wrinkles.[10]

Contact prints are usually more blurred than those obtained with a well focused camera, due to the condition that the sensitive emulsion cannot be placed in direct contact with the source of light, but is always at a distance away equal to the thickness of the glass. In some large tubes this thickness may be greater than a sixteenth

[1]Crawford. Photographing Transients with a Cathode-ray Oscillograph. *General Radio Experimenter*, Vol. 8, 1933, page 10.

[2]Wood. Recent developments in Cathode-ray Oscillography. *Journal Institute of Electrical Engineers*, Vol. 71, 1932, pages 41-56.

[3]Forster. Kathodenstahl oszillographische Aufnahme unmittelbar auf photopaper. *Zeitschrift für Technische Physik*, Vol. 13, 1932, pages 373-374.

[4]Knoll. Kathodenoszillographen Aussenaufnahmen mit Linse und Kamera. *Archiv für Elektrotechnik*, Vol. 26, 1932, page 131.

Knoll. Die Schwärzung photographische Schichten. *Archiv für Elektrotechnik*, Vol. 26, 1932, pages 132 and 214.

Rogowski. Die Schwärzung photographische Schichten. *Archiv für Elektrotechnik*, Vol. 26, 1932, pages 133-134.

[5]Friesewinkel. Uber das Verhältnis der Schwärzungen durch Schirmschrift und äussere Elektronenschrift. *Archiv für Elektrotechnik*, Vol. 28, 1934, pages 826-832.

[6]Wood. The Cathode Ray Oscillograph. *Proceedings Physical Society of London*, Vol. 35, 1923, pages 109-124.

[7]Wood. The Cathode Ray Oscillograph. *Journal Institute of Electrical Engineers*, Vol. 63, 1925, pages 1046-1056.

[8]Knoll. Leuchtschirm Kontakt photographie beim Kathodenstrahlenoszillograph. *Zeitschrift für Technische Physik*, Vol. 11, 1930, pages 491-493.

[9]Graupner. Uber die Schreibschärfe bei kathodenoszillographischen Lichtkontaktaufnahmen. *Archiv für Elektrotechnik*, Vol. 28, 1934, pages 323-325.

[10]Bown. Special Contour of Screen. U. S. Patent 1750661.

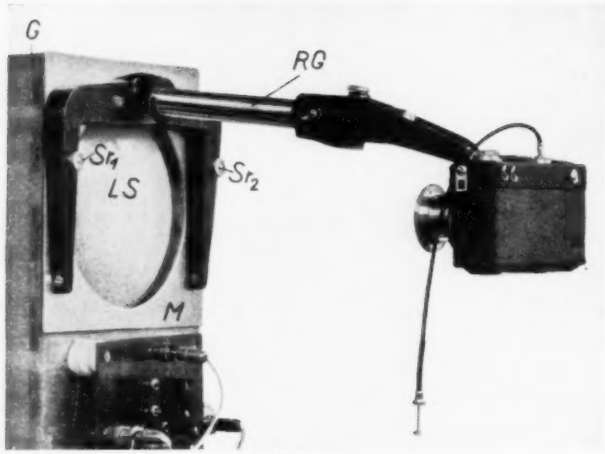


Fig. 2

of an inch, which allows each point of light to spread out and expose a spot on the film much greater than its own diameter.

The film selected should be sensitive to the color of the screen fluorescence. For such selection, use the data given in the Dec. 1935 article, particularly Table I and the curves of Fig. 1. Bromide paper is more sensitive than the usual printing paper.

Under average work conditions, the author has found that the best all-around paper to use is the ordinary photostat paper. It is commercially available in rolls, from which it must be cut up by hand. If an ordinary camera is used it is possible to redesign an old plate holder to hold pieces of this paper in the focal plane.

RECORDING WITH A CAMERA

Due to the aforementioned dispersion of light and consequent lack of clarity with contact prints, a lens camera is the commonest device for recording. With ordinary cameras, however, the diagram is usually much smaller than the diagram on the screen and therefore covers but a small portion of the film.

In using this method it is necessary that the room illumination be subdued and that reflections of any artificial lights or windows from the screen are not projected toward the lens, to appear as highlights.

If the curve under consideration is recurrent, where the spot continually retraces the same path, the technique of recording is less critical. A camera is mounted with the axis of the lens system coaxial with that of the tube. One such arrangement, used in Germany, is shown in Fig. 2. Here a "Contax" camera (a representative type of "candid" camera) is mounted on an adjustable bracket in front of the screen *LS*. While the negative obtained is reduced (about quarter-size), the nature of the reproduction is such that distinct and "contrasty" reproductions are obtained. The camera shown has a 5-cm. *F*/2.8 Tessar lens.[11]

Since the screen-to-lens distance is short, the lens must be carefully focused. It usually is necessary to prefocus on a ground glass screen in the focal plane of the film. An ordinary roll film camera can be used if preliminary focusing tests are made, and the exact operating position carefully noted. A portrait attachment will help. Cameras equipped with focal plane shutters are not desirable for this work.

To Be Continued

[11] Scheminzky. Die Photographie als Helfsmittel der Physiologie. *Photographie und Forschung*, Vol. 1, June 1935, pages 12-20.

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Adjustments of Electrical Instruments

Thirtieth instalment of "Electrical Measurements and Control." This series began in the January 1934 issue. See announcement on editorial page of November 1933 issue. All rights reserved by the authors.

By PERRY A. BORDEN and M. F. BEHAR
Member A.I.E.E. Editor, *Instruments*

Previous articles have contained thorough discussions of the sources from which errors in electrical instruments or in their use might be expected to develop, and there have been suggested precautions for minimizing these errors, particularly such as may arise from sources external to the instruments used. In this article particular reference will be made to those errors classed as "inherent errors" and means will be described whereby they may be eliminated, or minimized, or canceled by opposing effects purposely introduced into the measuring system. It is not the intention to convey the idea that these adjustments can be indiscriminately performed in the field, but it is felt that a knowledge of the expedients by which various adjustments are effected will help the user to appreciate the fact that the accuracy of measuring instruments is based on sound scientific principles, and that satisfactory operation is obtained only by the adjustments being carried out according to definite rules.

The principal adjustments required of every indicating and recording instrument are the following:

(1) Scale length.

(2) Scale proportionality.

(3) Zero.

Notes. (I) Fig. 47-1 has been prepared as a general reference in connection with the following three sections. (II) These statements do not apply to instruments of the ratio type, such as crossed-coil movements, etc. See Section 5 of March 1934 article.

1. Scale Length

The position of the pointer in an indicating instrument is determined by the action of two opposing forces, the measuring torque and the control torque. As pointed out in an earlier article of this series*, these forces in electrical instruments are generally derived from quite separate elements of the mechanism, the former originating in forces developed by the electrical magnitude under meas-

**Instruments*, March 1934, pages 45-55—particularly Section 1.

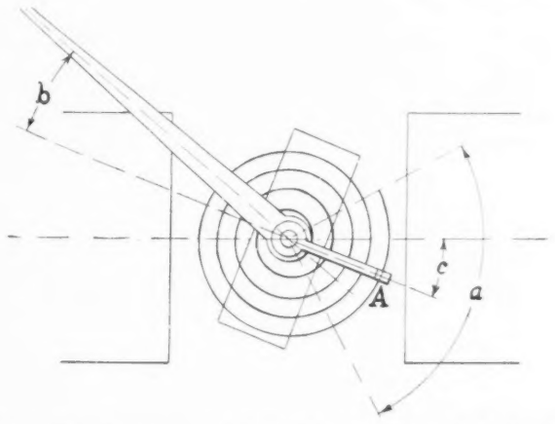

Fig. 47-1. Controlling Factors in the Calibration of a Direct-deflecting Instrument.

(a) Scale-length is corrected by altering the point within a limited angle *a* at which the spring is anchored to its abutment *A*.

(b) Proportionality is varied by changing the angle *b* between the pointer and the deflecting part of the movement.

(c) The position of the scale zero is varied by altering the angle *c*, representing the angular position of the abutment in relation to the stationary parts of the instrument.

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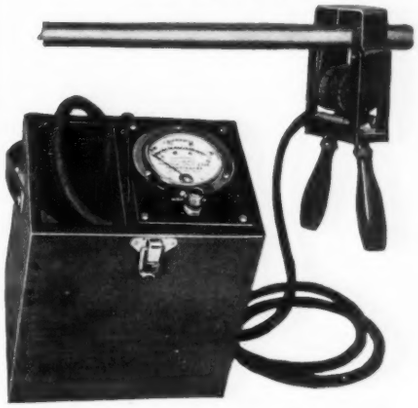

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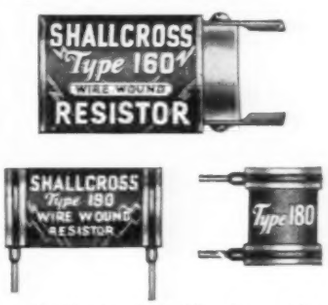

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urement, and the latter from a spring, weight, or other means arranged to oppose the measuring torque and increase its value as the pointer, pen, etc., departs from its zero position. Upon the development of torque in the measuring elements of the instrument, the moving part is deflected, causing the pointer to traverse the scale, and at the same time the spring or weight to develop a counter-torque. Mechanical arrangements are such that the counter-torque must increase with the deflection. If this were not so the pointer, once it had begun to deflect, would immediately swing to the end of the scale. The deflection of the movement continues until there is attained a balance between the deflecting torque and the counter-torque, at which time the position of the indicator represents the value of the electrical magnitude under measurement. In practically all portable instruments, and in most switchboard instruments, the counter-torque is derived from a spring; and the characteristics of this spring determine the extent to which the movement will deflect before a balance is obtained. Reference has already been made to the refinements which have taken place in the making of instrument springs, and the spring of any modern electrical instrument represents the manufacturer's opinion of the material, size, shape and heat-treatment best suited to the work in hand. It seldom is advisable to attempt adjustment of an instrument by changing any property of the spring. The only permissible alteration (and one which does not alter the spring itself) is the adjustment of the spring's effective length. As a long spring develops less torque for the same deflection than a short spring, it follows that lengthening the spring will have the effect of lessening the counter-torque, and thus increasing the travel of the pointer for the same amount of deflecting force. Briefly, this may be stated: "Lengthening the spring expands the scale, and shortening the spring contracts it." Some instruments are provided with a definite adjustment, whereby the spring may be gripped at various points on its length, and the scale length thus correspondingly varied. In making such adjustments, care must be exercised not to kink the material or to leave convolutions in contact; and experience has shown than when the point at which a spring is clamped is changed, the metal should be allowed some minutes to adjust itself to the altered local stresses before close readings are attempted. A spring remains a precise measuring device through a relatively limited range of stress, so that accurate results cannot be expected from an instrument in which it has been found necessary to make the spring abnormally short.

In gravity-controlled instruments, such as some types of recorders, the counter-torque is derived from a weight, so disposed that as the movement is deflected under influence of the measuring torque the effect of the weight in producing a counter-torque is increased. This may be accomplished by the weight changing its angular position with deflection, as in some direct-acting recorders with horizontal spindles, or, as in some relay types of recorders, by the weight being mechanically shifted along a horizontal lever arm as a part of a carriage. Adjustment of scale length in the former type may be accomplished by varying the distance of the weight from its center of rotation. In the relay type, if the weight is wholly borne by the carriage, adjustment may require taking away or adding material to the weight. In gravity-controlled relay-type recorders, such as the Westinghouse "Type G"* or the Baker totalizer†, the calibrating weight is carried on a link supported at one end by the carriage and at the other by a part of the power-moved mechanism, and the desired adjustment may be effected by changing the position of this weight on the link.

In voltmeters, wattmeters, shunted ammeters, or other instruments having resistors in series with the actuating windings, adjustment of scale length is in many cases effected by varying the resistance of the circuit. This generally requires the use of soldering equipment, but it is a positive way of accomplishing the adjustment, and is capable of precise results when expertly done. Since the temperature characteristics of such instruments are generally governed by the relative value of the resistances of the copper and other parts of the circuit, care must be exercised that temperature compensations are not thus disturbed when making adjustments by this method. One maker states that the better-grade ammeters will always have temperature compensation changed and possibly ruined by altering series resistor constants.

In instruments of the permanent-magnet moving-coil (d'Arsonval) type, the actuating force, and hence the scale length, may be changed by varying the strength of the permanent magnet. This provides a quick and effective factory adjustment; and some manufacturers make it a standard practice to assemble such instruments and make preliminary adjustments with over-strength magnets, which are later demagnetized under controlled conditions

*Instruments, January 1935, page 12.
†Instruments, February 1936, page 46.

until the instrument is brought to the proper calibration. It is seldom that this method can be used without the manufacturer's special facilities; and it can hardly be looked upon as a field adjustment for any type of instrument. In some makes and types of permanent-magnet instruments, however, there is provided an adjustable soft-iron shunt by which a few percent of the total flux may be diverted from the main air gap and a certain control thus effected on the scale length.

None of the adjustments of scale length should be attempted by any method other than the manufacturer intended should be employed.

2. Scale Proportionality

It frequently is observed that an instrument which had satisfactorily passed a previous inspection is found to be reading high at one point of the scale and low at another. The causes of this faulty condition are somewhat diverse, and in order to correct it, one must usually find the original cause and rectify it. The main causes are:

(a) Bending or shifting of the pointer;
(b) Distortion of the mechanism;
(c) Unbalance;
(d) Strains set up in the spring as a result of mishandling or overheating.

In most indicating instruments the pointer must bear a definite relation to the actuating part, whether the latter be a coil or an iron vane. If the pointer should become bent or should slip around on the shaft, a simple correction of the zero will not bring the indications into even approximate agreement with the scale markings. The only satisfactory way to rectify the error lies in correcting the mechanical displacement which may have taken place, or, failing this, in marking a new scale. A similar effect will be produced by displacement or distortion of some parts of the measuring element. Any cause which will change the conformation of the magnetic field or of the moving part, or the relative position of the two, is almost sure to introduce proportionality errors in deflecting instruments; and, as above, the correction lies in either rectifying the mechanical fault or providing a new scale.

In the construction of high-grade spring-controlled instruments, an effort is usually made to have the moving part in a state of balance as regards gravitational effect; but as this may necessitate tedious adjustments, the condition is seldom exactly obtained. As a consequence, errors (generally small) are likely to make their appearance when the instrument is tilted into another position than that in which it was originally calibrated. In switchboard instruments, which are usually calibrated in the same position in which they are finally installed, little trouble may be expected from gravitational effects; but with portable instruments it is well to exercise care that they are kept reasonably level when in use. An instrument intended for use with its shaft in a vertical position should not be used with the shaft horizontal (and *vice versa*) until the user has assured himself that the errors so introduced will be negligible. Modern high-grade instruments, particularly in small sizes, arranged for use on sloping panels, are usually balanced by the manufacturer in such manner that for any position in which they are likely to be used the gravitational error will not be sufficient to interfere with the intended results. A check of the balance condition may easily be made by placing the instrument in a number of extreme positions and observing the zero variations. In using instruments having a partial or complete gravity control it is imperative that the instrument always be leveled with care and maintained in the one position.

Because of relatively great errors in scale proportionality introduced by small changes in the physical relation of parts, a large percentage of the better-grade indicating instruments on the market, particularly of those having inherently non-uniform scales, are fitted with individually-calibrated hand-drawn scales. Thus, the scales of instruments of the one type and rating are likely to differ slightly in individual instruments, and will not be interchangeable. For the same reason, if repairs or alterations necessitating structural changes in an instrument have been made, it will frequently be found that the new calibration cannot expediently be brought into agreement with the original, usually necessitating the marking of an entirely new scale.

3. Zero

If accurate results or duplications of the original performance are desired from a measuring instrument, it is obvious that the zero point of the scale must be maintained. This precaution is frequently overlooked, with consequent erratic results in reading. The zero furnishes a datum upon which all other measurements are based; and if it is in error or subject to variation it is evident that

MANUFACTURERS' NEW LITERATURE

In this department we list each month the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm.

D160 **Measuring Wire Specifications.** The Van Keuren Co., 12 Copeland St., Watertown, Mass., have issued circular W 34 as a supplement to their catalog 29. This circular gives complete specifications for thread measuring wires as covered by the 1933 report of The National Screw Thread Commission (Bureau of Standards Miscellaneous Publication No. 141).

D161 **Solving Industrial Crimes, Case No. 11.** This bulletin illustrates the application of graphic instruments by a coal company for supervising the operation of electric shovels. Esterline-Angus Co., Indianapolis, Ind.

D162 **Thermometer Catalog.** 88-page Catalog No. 1250 contains useful information concerning the theory and practice of modern thermometry. It covers liquid-filled, vapor-tension, and gas-filled recording, indicating, and controlling thermometers, including the new small-bulb gas-filled thermometer. In connection with automatic temperature controllers, it gives information regarding both electric and pneumatic types, and helpful sketches to illustrate how they are applied. Application data are given on industrial stem thermometers, resistance thermometers, humidity measuring instruments, control valves, time-temperature controllers and the accessories that are used with thermometers on industrial applications. The Bristol Co., Waterbury, Conn.

D163 **Spectrographic Outfits.** 60-page book describes a new range of models of the Hilger Quartz Spectrographs. The small, medium and large models have all been redesigned and take the Hilger Accessory Bar for the correct alignment of accessories. The large instrument is now offered in a fully-automatic model said to be of great advantage in the industrial control of metals and alloys. A new spectrograph has been introduced, intermediate in size between the small and medium. An exceptionally complete range of accessories is described for both qualitative and quantitative analysis, including outfits for the Stepped Sector and the Lundegardh Flame Methods. Adam Hilger Ltd., 98 Kings Rd., London, N. W. 1, England.

D164 **Modernization the Trend in Industry.** 3-color folder describes the Brown Potentiometer Pyrometers. A list of the companies using a large number of these instruments is given. Brown Instrument Co., 4482 Wayne Ave., Philadelphia, Pa.

D165 **Free-Vane Controllers.** Bulletin No. 440 covers new series of Ampliset Free-Vane controllers for time-temperature, flow, liquid level, pressure, time-pressure and humidity. The Bristol Co., Waterbury, Conn.

D166 **Automatic Heating and Air Conditioning.** 48-page booklet entitled "This Thing Called Automatic Heating and Air Conditioning" gives a comprehensive consumer's story of the title subjects. Minneapolis-Honeywell Regulator Co., 4482 Wayne Ave., Philadelphia, Pa.

D167 **Micromax Electric Control.** 8-page catalogue describes a complete new control system for regulating input in proportion to demand. Based on potentiometer balance, this control consists of three parts: Micromax control instrument, relay detector and valve mechanism. Chief features of this control are said to be simplicity of design, adaptability to a wide range of applications, quick response to any deviation, and its smooth, dependable operation. Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.

D168 **Pyrometers.** 16-page Catalogue No. 1101B describes the photoelectrically balanced recorders, indicators, controllers and recording controllers manufactured by C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y.

D169 **Index to Bristol Catalogues.** 8-page Bulletin 435 is a pictorial index of bulletins and catalogues published by the Bristol Co., Waterbury, Conn.

D170 **Volume Control.** 1-page leaflet illustrates and briefly describes the Type 653 volume controls. General Radio Co., 30 State St., Cambridge A, Mass.

D171 **Photoelectric Reflection Meter.** 1-page leaflet briefly describes the Lange new photoelectric reflection meter of particular interest to the textile industry. Pfaltz & Bauer, Inc., Empire State Bldg., New York, N. Y.

D172 **Controlled Rectifiers.** 1-page bulletin 8602, describes controlled rectifiers providing d.c. power from an a.c. power supply for small public and private telephone systems. Ward Leonard Electric Co., 38 South St., Mount Vernon, New York.

D173 **Johansson Gage Blocks and Accessories.** Two folders: Form 7393-1 describes Set No. 1 which consists of 81 blocks and will make over 120,000 different size gages in steps of 0.0001" from 0.200" to 12". Form 7393 describes Set No. 2 which consists of 35 blocks and 4 accessories. This set will make 80,000 different size gages in steps of 0.0001" from 0.300" to >8". A table of areas of squares and circles is also included. Ford Motor Co., Johansson Division, Dearborn, Mich.

D174 **Cubicles.** 6-page bulletin GEA-2326 illustrates cubicles with FH oil-blast breakers for 15,000-volt service. This bulletin is profusely illustrated. General Electric Co., 1 River Rd., Schenectady, N. Y.

D175 **Spectrographic Analysis Instruments.** 32-page Catalog D-20 is a treatise on spectrography. It also gives a classified bibliography of 68 references on this subject. Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y.

D176 **Cenco News Chats.** May 1936 issue of this house organ describes a large number of interesting new developments: Hydrophil balance, the Universal high capacity temperature control unit, a synchronous timer, a new glass electrode pH meter, a high-vacuum pump, a cosmic ray counter, etc. It also "reviews" new 1636-page General Catalog and briefly describes Cenco's new buildings. Central Scientific Co., 1700 Irving Park Blvd., Chicago, Ill.

D177 **Electric Precision Timers.** 12-page bulletin No. 89 illustrates and gives specifications for a large number of different model timers. Standard Electric Time Co., Springfield, Mass.

D178 **Electric Vacuum Gage.** 4-page bulletin describes a Pirani type electric vacuum gage. It covers application, principle of operation, construction, calibration, etc. Winslow Engineering Co., 138 Sussex Ave., Newark, N. J.

D179 **Potentiometer Controllers for Industrial Temperatures.** 20-page bulletin 202 describes the Foxboro potentiometer controllers and their advantages. A number of installations are illustrated. Foxboro Co., 46 Neponset Ave., Foxboro, Mass.

D180 **Optical Pyrometer.** 4-page bulletin describes a new precision optical pyrometer. Hurl R. Adams, 4823 Alhambra Way, Pittsburgh, Pa.

D181 **Differential Relay.** 12-page catalog Section 41-405 covers the Type HA Ratio Differential Relay for high-speed generator and transformer protection. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

INSTRUMENTS
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Have me supplied with a copy of each piece of Manufacturers' Literature listed below.

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little reliance can be placed on indications at other points on the scale. The causes of zero displacement, as pointed out in a previous instalment, are usually mechanical, though sometimes stray fields or, in shunted instruments, thermo-electric effects, may produce a zero shift. In general it may be said that whenever the moving part of an instrument has sustained damage of any sort it is sure to be reflected in an abnormal shift of the zero. Though modern research in spring materials has done much to bring about the "perfect" spring, yet even the highest grades of spring-controlled instruments should have their zero indications carefully watched, and where necessary, corrected. It is to be remembered, however, that a zero error due to a bent pointer should not be corrected by moving the spring abutment but by straightening the pointer. (See prior chapters.)

In the ordinary deflecting instrument the spiral control spring is usually carried on the end of an arm adjustable about the center of rotation of the movement; and this adjustment, by varying the position of the stationary end of the spring, is capable of moving the pointer through a small angle in either direction, so that it may be brought to the correct zero position before observations are made. In practically all high-grade indicating instruments there is provided on the outside of the case an adjusting screw, so that zero may be corrected at any time without otherwise disturbing the instrument. Direct-acting recorders are usually provided with either a micrometer adjustment on the zero, or else a refinement in the form of an extended lever working over a graduated scale.

Where gravity is the controlling force, zero adjustment is generally accomplished by shifting a weight normally fixed to the moving element, so that this part will take up a new position of equilibrium when load is removed. As gravity control in American practice is now almost entirely confined to horizontal-shaft recorders, and as these are likely to be of more or less special design, details as to zero and other adjustments can generally be best obtained from the manufacturers' instruction books.

As a matter of policy it is advisable to check, and correct if necessary, the zero of an instrument after it has been subjected to any unusual condition, *or to any of its other possible adjustments.* If the zero error in any type of instrument is found to be beyond the range of adjustment provided, or if a sudden change of considerable magnitude is observed, one may be assured that it has been repaired. (However, before assuming that anything is wrong inside, first breathe on the glass to dissipate possible electrostatic charges.)

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